EVAPCO WHITE PAPER

SUBJECT: ASHRAE Research Project RP-1361

Biological Control in Cooling Water Systems Using Non-Chemical Devices

The University of Pittsburgh has performed, under the direction of ASHRAE Technical Committee 3.6, an investigation on the performance of non-chemical devices for biological control of very-small model cooling systems. The data indicated that none of the devices tested had a measurable effect on the biological activity in the very-small model cooling tower. This was quite unexpected since some of the devices, including pulsed-powered devices, have many years of documented success controlling microbiological populations (<10,000 CFU/ml) in full-size evaporative cooling installations.

This discrepancy between the field results and the very-small size test results were due both to an inherent problem with trying to mimic biological activity in very-small size systems and some conditions that occurred in the test at the University of Pittsburgh.

Biological Activity in Very-Small Size Systems

As you try to model operating systems with very-small size laboratory systems it is impossible to maintain all of the interrelated relationships found in a full size operating system. In evaporative cooling systems the most obvious interrelated relationship is the surface area to volume ratio. A cube 10" on a side has a volume of 10^3 or 1000 cubic inches and a surface area of 6×10^2 or 600 square inches. The surface area to volume ratio is then 600/1000 = 0.6. If we attempt to model this cube at a $1/10^{th}$ scale we would end up with a 1" cube. The volume of the cube would be 1 cubic inch and the surface area would be 6 square inches. The surface area to volume ratio of our $1/10^{th}$ model cube is then 6/1 = 6; ten times larger than the full-size cube. Biological activity in a cooling system is strongly influenced by biological growth on surfaces. Small systems have inherently more surface to volume than large systems and are inherently more difficult to treat.

The problem with very-small size tests was clearly demonstrated in a previous ASHRAE Research Report, RP- 954. Four non-oxidizing **chemical** biocides (isothiazoline, gluteraldehyde, DBNPA, and polymeric quaternary amine) and three oxidizing biocides (chlorine, bromine and ozone) were tested in a very-small size model cooling tower *using doses typical for cooling tower applications.* While some of the chemical treatments demonstrated some short-lived effects on heterotrophic plate counts most had little or no effect. The conclusion of the researchers in RP-954 was that, "**The heterotrophic bacteria remained largely unaffected by the biocides**". The problems associated with modeling biological activity in very small size cooling towers resulted with even the most common chemical biocides applied at normal doses being ineffective in controlling biological activity – the tests on very small size cooling tower models simply do not reflect known technology and results in full size operating systems.

For the past few years Evapco has been testing a variety of non-chemical devices on a very small size cooling system at its Taneytown Research Facility. Like the ASHRAE research, Evapco's testing has also shown that NCDs cannot control biological activity in very small size systems. In conjunction with this small-size testing, full-size testing was performed at the same time, in the same facility, using the same make-up water, and operating under the same environmental conditions. All of the full-size tests exhibited excellent biological control (< 10,000 CFU/ml) using pulsed-powered devices as the only form of water treatment. ASHRAE research reports RP-954 and RP-1361 have helped Evapco validate that the difficulties encountered in the Taneytown very-small size model installations are inherent due to the size of the system rather than an insidious problem in the testing methodology.

Specific Issues with the University of Pittsburgh Testing

There are several specific shortcomings with trying to apply the results from the Pittsburgh study on very-small size model cooling towers with full size systems. First, for the reasons discussed above, there must be a presumption that very-small model towers are harder to treat than full-size towers. This is an inherent problem with very-small size systems having aggressive biological activity. This problem is due to the much larger surface area to volume ratio present with very-small systems and was clearly demonstrated in ASHRAE Report RP-954. The model Plexiglas cooling tower used in the Pittsburgh study was at least an order of magnitude smaller than a full-size unit and as such would be more difficult to treat compared to a full-size system.

The second issue is the biological activity of the make-up water used in the Pittsburgh testing. The average heterotrophic plate count for the make-up water fed to the very-small towers was approximately 25,000 CFU/ml. Non-chemical devices are typically installed on systems using potable make-up water. Actual field test data of potable make-up supplied to typical cooling towers suggests the HPC is typically 0 CFU/ml and almost always less than 100 CFU/ml. The researchers point out that potable taps with sporadic use can have relatively high heterotrophic place counts because of biofilms which build and shed from the piping. This is in contrast to cooling towers which need a constant supply of make-up water. With the high and consistent make-up water flow going to a tower and with much larger diameter pipes than for a potable water tap (less surface area to volume on the make-up water piping) the HPC of make-up water is typically substantially lower than the make-up water used in this study.

The third issue is the chemical addition conducted to validate that the system could be controlled by chemicals. Chlorine, an oxidizing biocide, was chosen. Chlorine, if added in sufficient quantities, will kill all bacteria. That chlorine is a biocide is not the question; the question is if chlorine *added in quantities typical of what is used in a full-size cooling tower* will control biological activity. That question was never answered because the quantity of chlorine added to the system was not recorded or reported. The only comment relative to the chlorine feed rate required to impact the biological population was that a lot of chlorine needed to be added to maintain a measurable residual.

Conclusion

It seems that the old adage, "today's headlines and history's judgment are rarely the same", applies to the subject at hand. The combined information from both ASHRAE sponsored research projects is that neither chemical nor non-chemical water treatment is able to provide biological control for very small size cooling tower testing models. This was the implicit "headline" for both reports. However, the "true discovery" (i.e. history's judgment) becomes clear by considering the common test results of the two research projects which were conducted approximately six years apart. **The true discovery of these research projects is that water treatment in very small size model cooling towers does not accurately mimic full size operating results –** this is history's judgment, which is easily formed by simultaneously considering common knowledge about water treatment for full size operating systems and the test results of both research projects (RP-954 regarding chemical water treatment and RP-1361 about non-chemical water treatment).

Connecting the dots from ASHRAE's research projects, which were conducted six years apart, has helped Evapco understand the conflicting results of poor biological control in its very-small size laboratory towers and superior results in full-size operating systems.