



Non-Chemical Water Treatment for Cooling Towers

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Cooling towers dissipate heat through evaporation, using large thermal transfer areas wetted by recirculating water. They often provide the most cost-effective option for removing heat generated in manufacturing, power generation, and large, refrigerant-based air-conditioning systems; but the combination of heat, expansive moist areas, and recirculating water creates an almost ideal petri dish for bacteria and mold. In addition to creating occupant health risks (think Legionnaire's disease), this biofouling decreases the system's heat-extracting efficiency by accumulating as a biofilm on surfaces—causing microbe-induced corrosion and providing a substrate for the other bugaboo of the process: scale.

Scale forms when dissolved minerals (generally calcium carbonate) and other solids in the water crystallize on surfaces. This further reduces the system's efficiency by clogging water paths and insulating heat-transfer areas: a 1/32" (0.8 mm) layer of scale can increase energy use by close to 10%. Evaporation exacerbates scale formation, and adding make-up water introduces more minerals to the process. This is partially controlled by "blow-down," a process of replacing some of the solids-laden recirculating water with make-up water.

Treating cooling-tower water to prevent biological fouling, scale, and corrosion is a complex, highly monitored process. Most of the dirty work in the half-million cooling towers in the U.S. is accomplished with biocidal, conditioning, dispersant, and scale-inhibiting chemicals, including chlorine, various brominated compounds, phosphates, molybdenates, acids (including sulfuric acid), and zinc compounds (which are now banned for cooling-tower use in about half of U.S. states). While chemicals do get the job done, there are considerations beyond the tower. Regulations are increasingly stringent for chemical storage, handling, and disposal; in many jurisdictions, chemically treated cooling-tower blow-down water itself is regulated. There are also consequences to worker, public, and environmental health due to accidental spills, chronic chemical exposure (even at low levels), and bioaccumulation of persistent chemicals in the food chain. Reducing or eliminating chemical usage in the treatment of cooling-tower water is an appealing thought.

Various alternatives are being used, including ozonation, ionization, and UV light treatment, all of which kill bacteria. Another option is the Dolphin Series, manufactured by Clearwater Systems, LLC, of Essex, Connecticut. It exposes recirculating cooling-tower water to electromagnetic fields, strength-varied and pulsed 60 times per second. Magnets?



Photo: Clearwater Systems Corporation

A Dolphin System Series 2000 unit was installed at the Dare County Courthouse in Manteo, North Carolina, in October 2003 to replace chemical treatment in the air-chilling system.

“The non-chemical water treatment industry has a checkered past,” Jerry Ackerman, marketing director for Clearwater, acknowledged to *EBN*. “There have been a number of non-chemical water treatment system manufacturers with dubious products and practices.” To help clear the water, NACE International (originally the National Association of Corrosion Engineers) released the standard “Control Factors in Performance Testing of Nonchemical Water Treatment Devices” in 1997 as a criterion. Still, Clearwater keeps a careful distance from any association with fixed magnet technology.

The Dolphin system has no moving parts—it consists of a transformer panel with a PVC pipe assembly installed in the water’s recirculating path. While some claims about how the system works verge on the mystical, there does appear to be a sound basis in the underlying physical chemistry—a basis that is backed by sources outside the industry.

The Dolphin’s “pulsed-power” pipe assembly is wound with coils that “impart pulsed, high-frequency, electromagnetic energy” into the water, according to Clearwater’s literature. The pulsing electric field induces the coagulation of colloids—very small, electrically charged particles—which creates nucleation sites that encourage calcium carbonate to precipitate as a powder in the bulk solution rather than a scale on surfaces. The powder can settle in the tank or be filtered out of the system. This coagulation-precipitation activity also reduces bacteria counts by trapping bacteria within the crystal formation, an effect noted in water-treatment plants, which typically use lime or alum to induce coagulation.

The primary source of microorganism control is also the pulsed-power electric field. The Dolphin is a less powerful version of a cold pasteurization process developed in the mid-1980s by Maxwell Laboratories in California. Electromagnetic radiation pulses cause electroporation of bacteria cell walls—the same technology often used to insert drugs or DNA into cells for medical research, but applied in such a way that the pores fail to close so the cells can no longer function normally. The Dolphin’s use of electroporation is more effective at destroying bacteria in recirculating water systems than in single-pass systems.



Photo: Clearwater Systems Corporation

The Shawnee Mission Medical Center (SMMC) in Kansas City, Kansas, installed a Dolphin system on a cooling tower next to their child-care center.

Claims made about the Dolphin are impressive, to say the least: exceedingly low bacteria counts, virtually no biofilm, almost no corrosion or scale, significantly reduced maintenance, extended tower life . . . and no chemical use. “People have used our blow-down water to irrigate lawns or to flush urinals. We’re working with a couple people who are going to use the blow-down on green roofs,” Ackerman said. To some, these claims sound too good to be true, and a few leading green engineers whom *EBN* spoke with remain skeptical.

Nevertheless, the system has earned LEED® points for half-a-dozen projects, according to Ackerman, including DPR Construction’s offices in Sacramento, California. Peggy Fischer, project manager for DPR, told *EBN*, “It’s been about two years now, and we’re still impressed with the Dolphin system.” (LEED doesn’t directly address chemical or water use in cooling towers, so these points are earned for “Innovation in Design.” If blow-down water can be used for flushing urinals, there may also be points in “Water Efficiency.”)

The University of California at Davis has converted six cooling towers from chemical treatment to the Dolphin. John Hahn, assistant superintendent and refrigeration shop supervisor, told *EBN*, “We’ve eliminated the chemicals, the cost of the chemicals, and the labor involved with the chemicals; we’ve kept chemicals from going into the water treatment facility on the campus; and the treated water has actually cleaned the bundles and the inner housings. We have 67 cooling towers—if I had the budget, I’d convert them all right now.”

The cost of the system depends as much on cooling tonnage as on supply-water quality. “It’s an engineered system—you can’t just throw it up. It needs to be spec’d correctly,” Bob Lersch, president of American Chem-Free, Inc., in West Virginia, which sells the Dolphin system, told *EBN*. Chemicals cost more in some parts of the country, and water quality varies; but in most cases, according to Lersch, the system “costs between two and three years of chemicals.” He cites paybacks ranging from as little as six months to one expected to take seven years.

The number of installations of the Dolphin system in the U.S. and Canada since 1998 is approaching 2,000, and Clearwater Systems has an impressive client list that includes numerous Fortune 100 companies (even one that manufactures cooling-tower chemicals—Dow Chemical), the U.S. Department of Energy, and a score of hospitals, schools, and universities (including Yale). Even if how it works is confusing and perhaps not entirely proven, the Dolphin Series does seem to offer a great alternative treatment system for recirculating water systems, including cooling towers, boilers, and even display fountains.

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