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by POWER

How to Effectively Treat Power Plant Cooling Water with Fewer Chemicals

Power plants across the globe are looking for an alternative to traditional chemistry to manage the water used throughout the cooling process. An innovative non-chemical water treatment technology may offer just the solution.

Power plants have historically required a significant amount of chemistry to prevent fouling and maintain efficient operation. While chemicals have been established as the standard protocol for water treatment, they have always posed several risks and challenges to facility operators and the environment. Over the years various non-chemical devices have entered the market to provide an alternative to chemistry, but have produced little to no results, leaving the industry rightfully skeptical of alternative treatment options.

This article introduces Flow-Tech—a chemical-free technology originating from the oil and gas industry—and its rapid adoption by power plants across America to mitigate fouling issues and reduce chemical dependency. One plant that embraced the technology realized a 90% reduction in bacteria counts, reduced most of its chemical usage, minimized maintenance labor hours, improved safety of its personnel, and achieved annual six-figure savings while maintaining a consistent heat rate.

Electronic Water Treatment Technology

Flow-Tech Systems originally developed its patented electronic treatment technology for use in onshore and offshore oil and gas wells. Due to the mineral-rich water extracted during oil production, wells are vulnerable to extreme fouling, requiring costly maintenance shutdowns and chemical intervention. Working with two of the world's largest oil companies, the technology was successfully piloted across more than two dozen locations in 2011 to demonstrate effectiveness in preventing scale deposition. Today, the same technology is used around the globe to protect production and surface processing equipment, providing a low cost, safe, and environmentally friendly alternative to chemicals, saving millions in remediation work and lost production each year.

How It Works. The innovative technology is the first to legitimize chemical-free water treatment. The system is free from the constraints that otherwise compromise other non-chemical technologies. Flow-Tech transmits a pulsed low-frequency signal into the system, which then propagates throughout the entire piping network, effectively treating all the fluid, regardless of flowrate and size of the system. Flow-Tech is versatile in its non-invasive installation and is retrofitted with zero intervention or cutting of pipes. Once installed, the technology provides an omnipresent treatment ensuring systemwide protection.

The Problem with Chemicals. Chemical companies hold a firm grasp on the water treatment industry. Power plants and industrial facilities have had little choice but to rely on chemicals to treat their water and maintain their operation. Unfortunately for owners and operators, this model leads to a cycle of ongoing costs and increased exposure to dangerous chemicals.

Standard chemicals, such as scale and corrosion inhibitors, sodium hypochlorite, biocides, algaecides, dispersants, sulfuric acid, and sodium bisulfate, are among those commonly used to treat a plant's cooling system. For a single F-class power plant, annual chemical costs typically range from $50,000 to $250,000, and require up to a million pounds of chemicals every year. All of these contribute to the elevated risk of impacting the surrounding environment.

A Straightforward Installation Process

A power plant in the Pacific Northwest has utilized Flow-Tech for the last three years as an integral part of its water management process. The 248-MW 7FA.02 plant has a cooling water flowrate of 75,000 gallons per minute. Discharging directly into the Columbia River, plant management was advised to eliminate chlorine from its water treatment system and shift to bromine to comply with the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System requirements.

After following the recommendation, the plant experienced intense blooms of a chemically resistant form of filamentous blue-green algae. In response, chemistry remediation was required every other day. Cycles of concentration were increased to meet the necessary dwell time, causing silica scale on equipment.

The facility relied on a chemical treatment regimen consisting of biocides, algaecides, an expensive silica inhibitor, a corrosion and scale inhibitor blend, acid, and dispersant. Faced with strict discharge limits and rapid biological growth, the plant began searching for an alternative to the previously relied-upon chemistry.

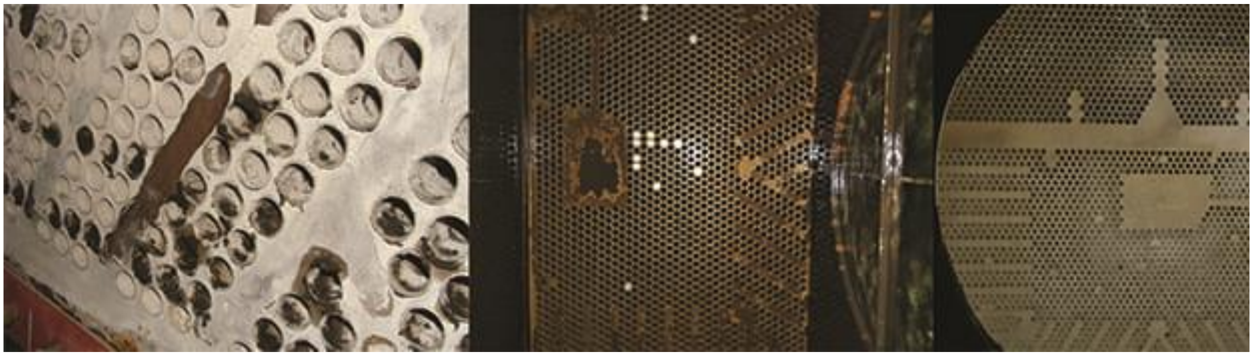
Over the course of a 12-month pilot, the facility worked with Flow-Tech to step down its chemical usage and reduce hold times, while managing the cooling water system accordingly. Implementing the technology while the facility was operating was essential. This was made possible by Flow-Tech's non-invasive installation process, which allowed three units to be mounted near, and connected directly to, the three 42-inch recirculation pumps (Figure 1). Commissioning of the system did not interrupt daily operation and was accomplished in a matter of hours.

1. Flow-Tech electronic treatment technology is installed through a non-invasive process. System components are shown here mounted on flanges on the discharge of circulating water pumps. Courtesy: Flow-Tech Systems

Successful Results

For the pilot to be deemed successful, the owners and operations team outlined the following objectives: no new scale formation on the condenser, maintain a bacteria count less than 10,000 colony forming units per milliliter (CFU/mL), and eventually reduce silica inhibitor, biocide, and algaecide injection rates.

Scale. Prior to Flow-Tech, mineral precipitation throughout the system consisted of 99% silica. Objectives were set to use 50% less silica inhibitor with no new scale formation for the duration of the trial. After three months of Flow-Tech operating in the system, the plant eliminated its use of the silica inhibitor. The end-of-year shutdown revealed the condenser tubes and auxiliary equipment to be clean of any new scale (Figure 2).



2. The image of the condenser tubes on the left was taken before installation of the Flow-Tech treatment system. The center and right-side images show a dramatic decrease in fouling after the Flow-Tech system was operated. Courtesy: Flow-Tech Systems

Flow-Tech is particularly effective where supersaturation events occur throughout the system. Supersaturation of the fluid with mineral ions means that it is saturated to capacity and only requires an extremely minute change in thermodynamic conditions to cause an accumulation of scale deposits.

Flow-Tech provides energy to the system so that charged solvated ions pick up additional energy from their kinetic interaction with Flow-Tech's treatment signal. This decreases the energy advantage that surface formation has and promotes formation of a higher percentage of scale as homogenous nanoparticles in the bulk liquid phase. This effect is strongest closest to the pipe wall, which is where it has the biggest impact in reducing scale growth and adherence. In doing so, it limits supersaturation by controlling precipitation with continuous deposition of nano, homogenous scale crystals, maintaining the cooling water in a non-supersaturated state.

Bacteria. Mitigating environmental impact was one of the facility's main priorities. Two months into the pilot, Flow-Tech reduced bacteria counts by 90%, clearing biofilm from the system. This allowed the extension of biocide treatment from 10 gallons every other day to eight gallons every five to 10 days. By the end of the pilot, biocides, algaecides, and dispersants were reduced by 50%. Minimizing the volume of chemicals discharged into the Columbia River allowed for a safe adjustment in discharge without posing an increased threat to the surrounding ecosystem.

Flow-Tech's unique ability to manage biological fouling is a result of two methods of physical attack. Through encapsulation, bacteria become encrusted in the precipitate that is held in suspension due to Flow-Tech's propagating signal. Similarly, through electroporation, the signal creates small holes in the cell walls damaging the bacteria. In either case, the bacteria struggle to reproduce and are ultimately killed or removed from the system via blowdown or filtration.

Since its founding, Flow-Tech has embraced third-party validation of its technology and claims. In 2008, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) commissioned a study through the University of Pittsburgh to evaluate chemical-free treatment systems and their effectiveness in controlling sessile bacteria (biofilm) in cooling water systems. Of the original technologies tested, no device showed the ability to control microbial growth rates compared to the control. After Flow-Tech Systems was incorporated in 2012, an evaluation was commissioned to test its system using the same protocol at the university. A 98% inhibition of sessile bacteria was achieved against the control. Flow-Tech is the only chemical-free system to pass this test to date.

In 2020, Montana State University's Center for Biofilm Engineering conducted a similar study. At the start-up of the experiment, both the test and control rigs were amended with Tryptic Soy Broth to encourage biofilm growth. By the end of the nearly two-month study, the Flow-Tech treated system had approximately 80% to 90% fewer live biofilm cells than the control system.

Algae. At its peak, the facility measured more than two feet of algae growth per day and required manual cleaning of the forebay trash screens as often as every two days. Each cleaning harvested nearly 4,000 pounds of algae and required a $3,500 crane rental. Both chemical and ultrasonic treatment methods were used in an attempt to control the growth with limited effect.

Screens were implemented to shade the basin, while Flow-Tech provided an indirect attack on the algae by reducing the bacteria—the algae's primary food source. The combined approach successfully reduced algae growth and allowed the facility to extend its algaecide treatment from every five days to every 20 days. Online cleaning of the forebay trash screens was no longer needed, eliminating the ongoing crane and labor costs.

Personnel Safety. With the elimination of cleaning-related hazards, the facility realized an immediate improvement to the safety of its personnel. Operators no longer required prolonged exposure to chemicals and the risk of spills was significantly mitigated.

Operational Efficiencies and Savings. By the end of the 12-month pilot, the facility's original objectives had been met and plant efficiency remained consistent. With more than a 50% reduction in chemical usage by the end of the pilot, the facility achieved annual six-figure chemical savings and eliminated manual cleaning costs that were no longer required. Three years later, plant heat rate has remained steady compared to the typical slow decline between outages caused by biofilm and silica scale under the previous chemical program.

A Proven Treatment System

Effective water treatment is crucial for a power plant's operation. With an ever-increasing call for sustainability, traditional chemistry limits a facility's ability to address challenges while meeting environmental goals. Facilities have a viable alternative treatment method to reduce or eliminate chemicals and to mitigate potential impact on surrounding ecosystems.

Flow-Tech provides power plants with an effective method of inhibiting fouling to improve operations, reduce maintenance, extend equipment life, and save water. Outside of power plants, Flow-Tech has continued its success in industrial applications including food and beverage, pulp and paper, legionella management, closed loops, and evaporative cooling. The technology is effective in residential and domestic water, agriculture, and is utilized by Fortune 100 companies for commercial heating, ventilation, and air conditioning applications.

*—**Mark Meyer** is the founder, **Gary Post** is an engineer, and **Kevin Brauer** is head of business development, all at Flow-Tech Systems. **Terry Toland** is the energy resource manager at Clark Public Utilities.*

Excerpt from March 2, 2021, post by American Museum of Natural History

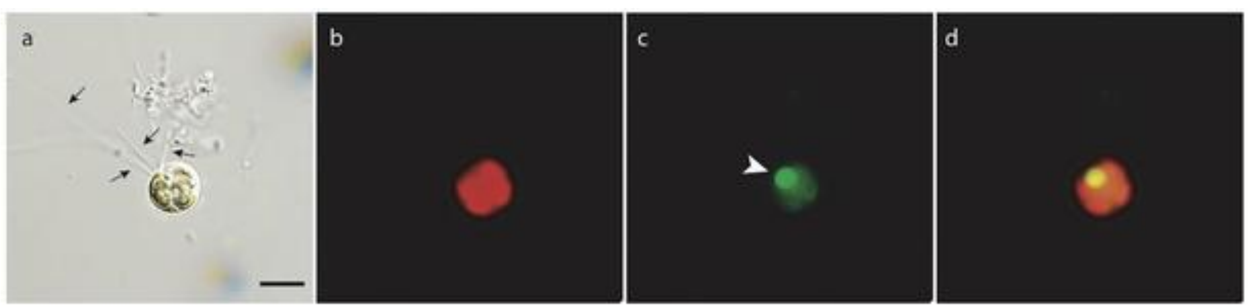
Museum Curator Eunsoo Kim studies how green algae seeks out energy through cell-eating, or phagocytosis.

In 2013, Museum Curator Eunsoo Kim and colleagues were the first to provide definitive proof that green algae also eat bacteria, showing alga sought out energy from gobbling up other organisms in addition to converting light into food through photosynthesis.

Now, Kim and researchers from Columbia University and the University of Arizona have published new work suggesting that phagocytosis (cell-eating) is likely more widespread than previously thought.

“Traditionally, we think of green algae as being purely photosynthetic organisms, producing their food by soaking in sunlight,” said Kim, an associate curator in the Museum's Department of Invertebrate Zoology and one of the corresponding authors of the study, which is published today in *The ISME Journal*. “But we’ve come to understand that there are potentially a number of species of green algae that also can eat bacteria when the conditions are right. And we’ve also found out just how finicky the are as eaters.

”Following the 2013 study, Kim’s lab continued to look for other types of green algae that use both photosynthesis and phagocytosis to power themselves. This was a difficult task until the research team devised a new experimental approach focused on live bacteria labeled with a non-toxic fluorescent dye.



Light and epifluorescence microscopy images of *Pterosperma cristatum*. The prasinophyte cells were fed with fluorescently labeled bacteria. The characteristic shape of the cells with their flagella (black arrows) were captured with the differential interference contrast optic (a). Red shows autofluorescence from the chloroplasts (b). The green spots localized close to the base of the flagella (white arrow heads), observed with green fluorescence, indicate ingestion of fluorescently labeled prey (c). An overlay of green and red fluorescence images indicates the relative localization of the feeding compartment within the cells (d). Scale bar: 10 µm.
N. Bock & E. Kim

They then combined the bacteria with five strains of unicellular green algae called prasinophytes inside a flow cytometer, which helps scientists analyze cell properties in solution. The flow cytometer measured increasing levels of green fluorescence in the algal cells over time, suggesting that the algae were consuming the glowing bacteria. To confirm that ingestion was actually occurring, they peered inside of the algal cells with high-precision microscopy.

The researchers uncovered two particular quirks about the finicky eaters: the algal strains they tested only ate live bacteria, and they ate more when the levels of other nutrients were low. These findings have large implications for the environmental study of green algae.

“Traditionally when people study bacterial ingestion by algae in the oceans for environmental samples, they use fluorescently labeled bacteria that have been killed in the labeling process,” said Museum postdoctoral researcher Sophie Charvet. “At least for the five algal strains we had in culture, they preferentially feed on the live bacteria and seem to be snubbing the killed bacteria. This means that the impact of algae on bacterial communities in their natural environment has possibly been underestimated drastically because of the methods used."….

excerpt from 2013 study:

…. The alga draws bacterial cells into a tubular duct through a mouth-like opening and then transports these food particles into a large, acidic vacuole where digestion takes place. The complexity of this feeding system in photosynthetic modern alga suggests that this bacteria-feeding behavior, and the unique feeding apparatus to support it, descend from colorless ancestors of green algae and land plants and may have played important roles in the evolution of early photosynthetic eukaryotes, the precursors to plants like trees and shrubs that cover the Earth today.