General Services Administration
Public Buildings Service

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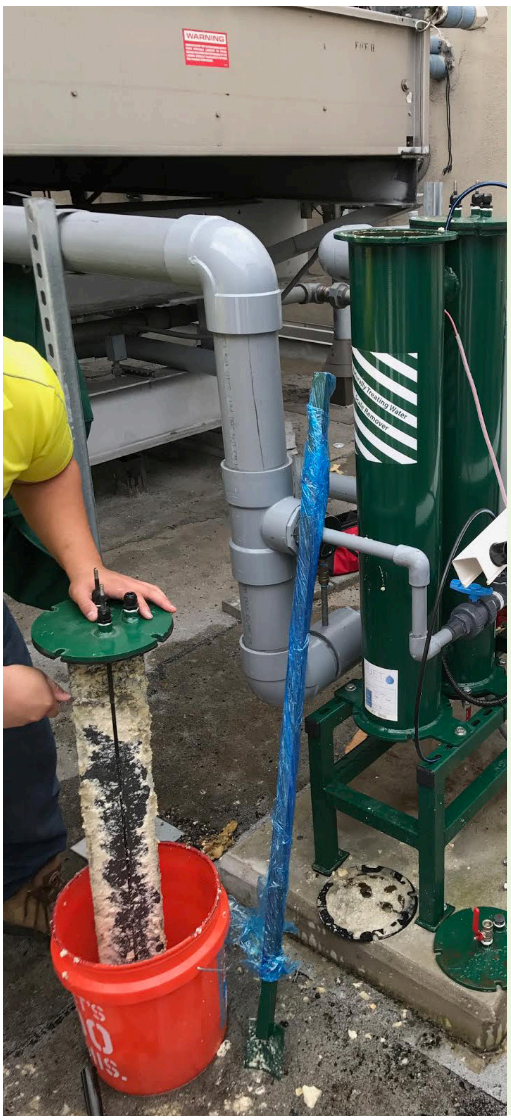
AWT: ELECTROCHEMICAL FOR COOLING TOWERS



Non-Chemical Water Treatment Uses Electrolysis to Sequester Scale and Create a Natural Biocide

Cooling towers are used in chilled water plants to transfer waste heat to the atmosphere through evaporative cooling. As water evaporates in open cooling towers, mineral content suspended in the remaining water becomes increasingly concentrated. When the remaining water can no longer hold the minerals in suspension, scaling and corrosion result. Consequently, system water must be flushed periodically, a process known as “blowdown,” to minimize mineral build-up. Typical cooling-water treatment adds chemicals to minimize scaling and corrosion and mitigate biological growth. GPG, working with the National Renewable Energy Laboratory, tested an alternative water treatment (AWT) technology that uses electricity to create a chemical reaction. The electrochemical process simultaneously reduces scale and creates chlorine, which acts as a biocide, thereby reducing or eliminating the need for both blowdown and added chemicals. During the early phases of GPG’s assessment, site personnel at the Juliette Gordon Low Federal Building in Savannah, Georgia, where the assessment was conducted, were concerned that removing biocides would result in a build-up of algae in the cooling towers, but in the end they found the opposite to be true: the alternative water treatment kept algae in check resulting in cooling towers that were cleaner and in need of less maintenance. Researchers measured a 32% reduction in makeup water, a 99.8% reduction in blowdown and a 100% reduction in added chemicals. At the GSA average water/sewer cost of $16.76/kgal and normalized installation costs, payback was 2.5 years.

The GPG program enables GSA to make sound investment decisions in next-generation building technologies based on their real-world performance.

INTRODUCTION

A. Scale buildup

B. Removing the reactor rod

C. Cleaning the rod

Cleaning the Reactors

Instead of scale build up in piping, this technology collects it on the reactor, which is easily cleaned.

A. Reactors show magnesium and calcium buildup after 3 months of operation.

B. Reactor rod is removed for cleaning.

C. Removing scale off each rod took about 10 minutes.

"It was very gratifying to see the scale buildup on the reactor tubes instead of in the piping or the cooling tower. O&M staff were able to clean the mineral deposits from the tubes in less than two hours."

—Todd Kronlein
Mechanical Engineer, PE, CEM, LEED AP
Southeast Sunbelt Region 4
Atlanta, Georgia

What is This Technology?

ELECTROCHEMICAL PROCESS INHIBITS SCALING AND DELIVERS A NATURAL BIOCIDE

The water treatment system's reactor uses 15 amps of direct current to create an acidic solution at the anode (a titanium rod) and a basic solution at the cathode (the reactor shell). The process promotes scaling of hard minerals and silica in the relatively-easy-to-clean reactor instead of in chiller condenser tubes and the cooling tower itself. Additionally, this process strips hydrogen ions from the chloride naturally present in water and creates chlorine, which acts as a biocide and eliminates the need to add other chemicals to the water. The technology does not treat the entire cooling water stream, but only a fraction of the total flow, through a side stream. The size of the system depends on cooling tower capacity and water condition but it can be retrofitted to any process water system. The technology for measurement and verification was provided by Dynamic Water Technologies.

What We Did

REPLACED TRADITIONAL CHEMICAL TREATMENT IN TWO COOLING TOWERS

The technology was installed in a chiller plant with two 150-ton cooling towers at the 242,000 ft^2 Juliette Gordon Low Federal Building in Savannah, Georgia. Prior to the installation of the electrochemical process water treatment, the building used traditional chemical water treatment. Researchers established baseline data in June and July of 2017. They evaluated the electrochemical process water treatment system during 2017's peak cooling season, from July 18 to October 23, when chillers were operating on a regular basis. Energy measurements included the electrical energy from the chillers, chiller water pumps, condenser water pumps, cooling tower fans, and the energy used by the reactor and side stream pumps. Make-up water and blowdown were also metered, and water consumption was recorded daily for both the baseline and the testing periods.

FINDINGS

31.6% WATER SAVINGS AND 99.8% REDUCTION IN BLOWDOWN A 99.8% reduction in blowdown and a 31.6% reduction in water use, saved $7,531 per year at the testbed water/sewer cost of $6.64/kgal. Savings increase to $19,003 per year at the GSA average water/sewer cost of $16.76/kgal.

ENERGY SAVINGS NOT EVALUATED AT THE TESTBED Alternative water treatment systems can save energy by reducing scale build up on process piping. At the test-bed site, electricity savings were not observed because the chiller was cleaned prior to testing and scale build up did not occur during the baseline monitoring period. Energy savings may still exist where substantial condenser tube fouling exists. The manufacturer estimates 5% to 15% savings from cleaner condenser tubes.

100% REDUCTION IN ADDED CHEMICALS; INCREASED COST FOR O&M CONTRACT Eliminating added chemicals saved $4,080 per year. In addition, the technology generates chlorine and lessened the buildup of a dark slimy substance thereby reducing the need for cooling tower cleanings from four per year to two per year, with estimated annual savings of $1,200. Savings are offset by an annual maintenance contract of $6,000. This cost includes quarterly site visits for preventative maintenance and reactor cleaning, as well as all consumables, water analyses and monthly water reports. Utilizing the manufacturer's service contract doubles the system warranty, from 5 to 10 years.

STRAIGHT-FORWARD INSTALLATION The technology has a small footprint and a simple tie-in process. One potential challenge is getting the equipment to the roof, where most cooling towers are located. At the test-bed location, the system had four 5-foot tall reactors mounted on a 4ft-by-1ft skid and weighed just under 500 lbs. The size of the equipment and the number of reactors will vary based on cooling tower size and water condition.

MAINTAINS WATER QUALITY The only constituent in the water that did not meet GSA standards was chloride. Chloride levels rose from 92 parts per million (ppm) to 400 ppm. As the concentration of chlorides increases, stainless steel corrosion can occur, although levels below 1,000 ppm are generally not concerning.

LIFE-CYCLE COST-EFFECTIVE At the low water/sewer rate in Savannah of $6.64/kgal, and with normalized installation costs, payback for a retrofit was 6.7 years, with a Savings-to-Investment Ratio (SIR) of 2.3. At the GSA average water/sewer rate of $16.76/kgal, the retrofit payback would be 2.5 years with an SIR of 6.

CONSIDER FOR ALL COOLING TOWERS The technology can be retrofitted to any cooling tower. It will be most cost-effective for cooling towers with at least a 200-ton capacity and high water costs.

Electrochemical Water Treatment Return-On-Investment

Rebates for AWT systems are available through some local water utilities

	Testbed (Before)	Testbed (After)[1]	GSA Normalized (After)[2]
Equipment (S)	N/A	$30,340	$30,340
Installation ($)	N/A	$29,029	$15,000
Maintenance (yr)	$5,280	$6,000	$6,000
Maintenance Savings (yr)	N/A	-$720	-$720
Water Consumption (Gallons/yr)	3,588,156	2,454,299	2,454,299
Water Savings (Gallons/yr)	N/A	1,133,857	1,133,857
Water Savings ($/yr)	N/A	$7,529	$19,003
Simple Payback (yrs)		**8.7**	**2.5**
Savings to Investment Ratio		**1.7**	**6.0**

[1] Savannah testbed water/sewer $6.64/kgal [2] GSA average water/sewer $16.76/kgal, normalized installation cost

CONCLUSIONS

These Findings are based on the report, " Electrochemical process Water Treatment for Cooling Towers" which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

Technology for test-bed measurement and verification provided by Dynamic Water Technologies.

What We Concluded

WITH RAPIDLY RISING WATER RATES, ALTERNATIVE WATER TREATMENTS SHOULD BE CONSIDERED

Water is GSA's fastest rising utility cost. In the past three years, GSA's water costs have increased 41%. And because 28% of all water used in commercial office buildings is attributed to cooling towers or other HVAC systems, new alternative water treatments that decrease blowdown are important to consider. The electrochemical process water treatment system evaluated here reduced blowdown by 99.8% and effectively treated the water without the expense of added chemicals. The technology will be most cost-effective in facilities that have high water costs or are located in areas where water is excessively hard, has high pH values and/or large amounts of total dissolved solids. Such places typically use more water and chemicals. Rebates for AWT technology are available through some local water utilities, making them even more cost-effective.

Lessons Learned

ADDITIONAL INSTALLATION COSTS

Because the electrochemical process system requires compressed air and because GSA does not allow tying into the building air system, a separate compressor is needed, though this expense is minimal.

MINIMAL RISK

Since the installation and the removal of the technology do not permanently alter the system, risk is low. The side stream water treatment system can be valved out and chemicals re-introduced at any time.

RELATIONSHIP BETWEEN CoCs AND WATER SAVINGS IS NOT LINEAR

Cycles of Concentration (CoCs), the ratio of solids in the blowdown water to solids in the make-up water, is a metric used to represent water consumption in cooling towers; high CoCs are related to low levels of blowdown and vice versa. Typically, CoCs for GSA facilities using traditional chemical water treatment are between 3 and 6, indicating a relatively high volume of cooling tower water consumption, mostly in the form of blowdown. During the Juliette Gordon Low Federal Building assessment, blowdown was reduced to almost nothing, testimony to the technology's effectiveness, and CoCs increased to above 200. It's important to note that the relationship between CoCs and water savings is not linear. Modeling indicates that the vast majority of water savings are achieved at lower CoCs: 92% of the savings achieved at 30 CoCs are captured at 15 CoCs.