

Cooling Tower Water Management

TAB11/07

Cooling tower water systems are subject to corrosion, scaling, deposition, and biological fouling; which increase operating costs due to downtime and equipment replacement, increased water and energy usage, process slowdown or upset, and pathogenic organism, such as Legionnaires' Disease, growth. Chemical products, control systems, bypass filtration, and pretreatment of makeup water are utilized in integrated water management programs to economically control these problems. Selection and application of the various technologies for a water management program must account for individual system design; system metallurgy; makeup water chemistry; control system design; program objectives; water conservation; economics; and environmental, health, and safety concerns.



Typical HVAC Cooling Tower Installation

ProChemTech International, Inc., was founded in 1987 to provide industrial, commercial, and government clients with a reliable supplier for the effective quality chemical products, control equipment and systems, system design, pretreatment and bypass equipment, and professional technical support needed to safely operate cooling tower water systems cost effectively without scale, corrosion, and biological problems; and with minimal environmental impact. The firm is organized as a “single source” supplier, utilizing its capabilities in specialty chemical and equipment design and manufacture, systems design, research, environmental services, analytical services, and engineering to devise complete water management programs. The proprietary chemistry and unique technology integration obtained by ProChemTech provides its customers with the most cost effective solutions possible for the many problems which can result from operation of cooling tower systems.

Cooling tower water management begins with an understanding of the cooling process, which depends upon evaporative heat removal from the cooling system.

Blowdown - Intentional Water Loss from Cooling Systems

Evaporative cooling water systems reject 75 to 80% of their heat load by evaporation of water. As the water evaporates, removing heat from the system, the dissolved solids present in **makeup** water, added to replace the evaporated water, become more concentrated, at some point exceeding the solubility limit(s) of the solids present (usually calcium carbonate) which results in precipitation and formation of undesirable **scale**. **Blowdown** is water intentionally drained from the system to restrict the buildup of dissolved solids to levels below the precipitation point. **Cycles** is the term used to denote the concentration of dissolved solids in the system water as compared to the makeup water, thus two cycles indicates that the dissolved solids in the system water are twice the level in the makeup water. Conductivity is generally used as an easy to measure substitute for dissolved solids to calculate cycles.

Blowdown constitutes a large cost, and major environmental impact, from system operation as it is "wasted" water, water run to sewer that must be replaced with fresh water. For instance, a 1000 ton rated cooling tower running at two (2) cycles will evaporate 26,600 gpd with a blowdown of 26,600 gpd. If the cycles are increased to four (4), the blowdown would be reduced to 8,867 gpd. Blowdown is the major system loss point for scale and corrosion inhibitors.

$$\text{Evaporation} = 26.6 \text{ gpd/ton cooling}$$

$$\text{Blowdown} = \text{Evaporation}/\text{Cycles} - 1$$

Scale Control



Typical Hard Water Scale

Since increasing cycles generally results in solubility limits being exceeded, acid or a scale inhibitor must be added to the water to prevent scale formation. In practice, acid is not recommended due to health/safety and control issues, while use of scale inhibiting products generally limits the system to a maximum of six (6) cycles, without bypass filtration. Using the 1000 ton system example, operation at six (6) cycles would reduce the blowdown to just 5,320 gpd. **Operation at more than six (6) cycles can seldom be justified on either environmental or cost reasons, and is technically challenging.**

Chemical Scale Inhibitor Use

A common misconception is that it is "bad" for the environment to be adding "chemicals" to cooling water. Fortunately, this is incorrect as the truth of the matter is that the effective phosphonate – polymer scale inhibitor chemistry we use have very low toxicities and are completely biodegraded when discharged into the environment. Thus use of scale inhibitor products in cooling towers does not adversely impact the environment. **In fact, when used to increase cycles, scale inhibitor chemical use reduces the environmental impact of system operation by lowering the amount of fresh water used and blowdown discharged.**

A second environmental benefit, often very substantial, is that by keeping the heat exchange surfaces in the system free of scale, energy use, and resultant environmental pollution from energy production, is reduced. For instance, a scale thickness of just 0.08 inches can increase energy usage in a chiller condenser by as much as 12%, a costly waste that can be totally prevented by proper scale inhibitor chemistry.

In situations where water is in short supply or discharge regulations are extremely strict, blowdown can be reduced, or eliminated, by softening of the makeup water and increasing cycles. At the point where **windage** loss, the small amount of actual water removed by passage of air through the cooling tower equals blowdown, the system will go into "zero blowdown". Generally, zero blowdown is obtained between 12 and 20 cycles. Due to the high corrosivity of cycled soft water, specialized chemistry is required for corrosion control while bypass filtration is mandatory. A recent study for the City of Tempe, AZ, shows a water use reduction of 756,000 gpy on a 176 ton cooling tower by going from three (3) cycles to zero blowdown.

ProChemTech is the experienced world leader in zero blowdown, softened cooling tower makeup water technology furnishing a complete “single source” technology package: water softeners, bypass filters, and the specialized water treatment chemistry required.

Corrosion Control

Most cooling water systems have substantial amounts of metal, such as steel, copper, and zinc, used in their construction. Uncontrolled corrosion of these metals will not only destroy the cooling water system over time, but will also have an adverse effect on the environment by discharge of these metals via system blowdown. While some corrosion inhibitors, such as molybdate and phosphate, can have an adverse environmental impact, controlling corrosion within systems is a decided benefit to the overall ecosystem due to reduced metals discharge to the environment and avoidance of the environmental impact resulting from premature replacement of corrosion damaged systems.



Corroded Steel Condenser End Bell



White Rust on Zinc Corrosion Coupon

and has proven to be very effective in both hard and softened makeup water applications for control of white rust corrosion of galvanized steel.

White rust has become more of an issue as cooling towers are operated at higher cycles and/or with softened makeup. This accelerated corrosion of galvanized steel takes place anytime the cooling water pH exceeds 8.2 with the rate of corrosion controlled by the alkalinity of the water, higher alkalinity increases the rate of corrosion. In 1995 ProChemTech discovered a specific chemical compound which functions as an inhibitor of white rust **corrosion**. This proprietary compound has been incorporated into many Company products under the name “**ZincGard**”

By careful selection of corrosion control chemistry to account for environmental impact, our water management programs are designed to have no adverse environmental impact and provide, using either hard or softened makeup water, **corrosion rates below 2 mil/yr steel, 3 mil/yr zinc, and 0.2 mil/yr yellow metals** as measured by corrosion coupon studies using standard NACE methods.

Biological Control – Biocide Dangers

Warm cooling water is an excellent place to grow microorganisms, including pathogens such as legionella. This growth causes severe system problems related to risk of Legionnaires’ Disease, system plugging, accelerated corrosion, and reduced heat exchanger efficiency. Typically, microorganism growth in systems is controlled by routine addition of toxic chemicals, **biocides**, to the system, which kill the microorganisms.

Millions of pounds of toxic biocides are used each year in cooling tower systems located in our towns and neighborhoods, creating a substantial potential for environmental and safety problems from transportation and usage spills.



Algae Growing in Cooling Tower Basin

Following addition to systems, the biocides are subsequently discharged in the blowdown to the public sewers, thus reaching our streams and lakes. **The use of biocides in cooling tower systems thus constitutes the major environmental impact from cooling system operation due to potential damage from accidental spills and routine discharge of toxics in blowdown.** Toxic biocide use is also a substantial health/safety issue for all the workers involved in the handling/use of such products as they are very toxic to people!

Many microorganism control technologies are presently marketed as "green". These methods, such as copper-silver ionization, ozone, and the various non-chemical device gadgets; either have a substantial environmental impact themselves (copper and silver ions discharged in the blowdown!), present major health and safety problems (ozone requires high voltage electrical generation and ozone is toxic), or, in the case of non-chemical devices, just do not work.

The best way to eliminate the environmental and safety problems resulting from biocide use in cooling systems is our patent pending "**ElectroBrom**" biocide system, which generates a non-hazardous aqueous solution of electrolytic bromine on-site from a non-toxic table salt and sodium bromide solution via electrolysis. After addition to the cooling system, the generated electrolytic bromine reverts back to the starting non-toxic bromide ion (present in sea water at 65 mg/l) in a short time, thus eliminating discharge of toxics in the blowdown. This economical to operate technology thus eliminates both the environmental impact from controlling biological growth in systems and worker health and safety issues from handling of toxic biocides. Units are available for systems from small HVAC installations to power plants. Shown at right is an electrolytic bromine unit sized for a 90 MW power station.



Since 1993, when we started marketing liquid stabilized bromine (PCT 3026), it has been demonstrated that a single oxidizing biocide is an effective means of controlling biological growth in cooling towers. The typical practice of using dual biocides is not needed and the many health, safety, and environmental problems inherent in use of multiple persistent toxic biocides can be eliminated.

System Control

The best chemistry will not provide satisfactory water management program results without effective control of system operation. First priority in any water management program is reliable control of system cycles. The best means to control cycles in cooling tower systems is via measurement of cooling water conductivity and activating a blowdown valve at a set point to discharge concentrated cooling water to sewer. Subsequent addition of lower conductivity makeup water follows until the measured conductivity decreases to a value below the set point.

We utilize automatic units for this function, under OEM agreements, manufactured by several firms such as Advantage Controls, LMI, Lakewood, and Hanna.

Scale and corrosion inhibitor, as well as biocide, dosage to cooling systems must also be carefully controlled to prevent scale, corrosion, and deposition; as well as any adverse environmental effects from over or under dosing, and to control the program operating cost. A good method to control scale and corrosion inhibitor dosage is generally referred to as proportional control, which is simply a process where the amount of makeup water added to the system is metered and the inhibitor products are fed in direct proportion using chemical pumps drawing directly from product shipping containers or day tanks.

Biocides are generally best added on a “shot” basis to obtain the best “kill” by obtaining a high level of product over a short time period. Such a dosing scheme avoids the development of biological immunity commonly observed when low levels of product are maintained on a consistent basis. We have found that automation using a programmable timer and chemical pump feeding directly from the biocide container, or activation of an ElectroBrom unit, gives the best results. Thus a typical biocide program would feed product on Monday, Wednesday, and Friday for a set time period to obtain a “killing” concentration of product.

Control testing of scale and corrosion inhibitors was at one time easy using either chromate or molybdate content of the product as an easy to test for tracer. Due to environmental and cost reasons, both of these easy to test for materials are not used to any great extent in cooling water treatment products. The various test methods for the high performance phosphonates and polymers, which are basis for most cooling water treatment products, are difficult to use and inaccurate at best with scale and corrosion problems often resulting from poor control due to inaccurate test results. Responding to this challenge, ProChemTech invented an organic patent pending colorant technology, “**BlueTrace**” in 2005. This technology has proven to be very successful as it provides for quick, accurate, and low cost testing of any traced product using a simple hand held spectrophotometer.



Continued work on the **BlueTrace** technology has resulted in complete automatic control of chemical inhibitor concentration in cooling towers by development of the **BlueTrak I** unit in partnership with Advantage Controls. The **BlueTrak I** uses an on-line laser diode spectrometer to determine the amount of product in the cooling water, compares this value to the set control limit, and adds product as needed to automatically maintain the set control level.

Shown at left is a complete panel mounted **BlueTrak I** controller.

Development of this exciting new technology continues with Advantage working on incorporating both conductivity blowdown and timed dose biocide feed into one compact **BlueTrak I** controller, giving the first true, economically priced automated cooling tower water chemistry control system that provides real time inhibitor monitoring and control, conductivity blowdown control, and timed biocide feed.

Non Chemical Devices (NCD)

In the past fifty years a substantial number of NCD gadgets for treatment of cooling water have been marketed. These gadgets claim to control scale, corrosion, deposition, and biological growth, with no adverse environmental impact, in cooling tower systems by a variety of processes described as magnetic, electrostatic, hydrodynamic, pulsed power, electromagnetic induction, ionization, and zeta potential; among others.

Numerous studies by various government agencies and industrial firms over the years have shown that all of these gadgets are of no practical use in water treatment. Careful review of gadget literature shows that their operation is not based upon any accepted scientific principals while the only evidence offered to substantiate acceptable performance is in the form of testimonials. We have investigated NCD gadgets for many years, the results are summarized in an International Water Conference Paper, "Non Chemical Devices: Thirty Years of Myth Busting", IWC-04-22, 2004. Our results are in agreement with all other reputable investigators, these devices simply do not work as advertised.

Laboratory Support

Design of a cooling tower water management program starts with accurate analysis of the makeup water, which requires a first class laboratory equipped with state of the art equipment. We are proud of our association with Analytical Services, Inc. (ASI), located in our headquarters building in Brockway, which is just such a laboratory. The staff of degreed chemists at ASI performs our analytical work using the best equipment available such as atomic absorption spectrophotometer, argon plasma mass spectrometer, ion chromatograph, gas chromatograph mass spectrometer, and a full wet and bio lab. ASI is both state and ISO certified.



Even well managed cooling tower water programs can experience problems due to equipment failure and changing conditions. ASI is well equipped for very fast turn around analysis of scale, deposits, corrosion products, and biological fouling, which aids in timely correction of problems.

Accurate chemical analysis of scale, as shown at the left, permits rapid identification of the cause of the scale and corrective measures. The analysis also permits a decision to be made as to use on-line cleaning, or acid cleaning, for its removal and which acid chemistry to use.

We would also note that an excellent analytical laboratory is a needed component of an active research and development program, as carried on by ProChemTech since 1987, to develop such products as ZincGard, ElectroBrom, and BlueTrace. Continued product innovation is needed to provide our valued customers with economical, high performance cooling tower water management programs given evolving changes in water quality and availability.

Field Support

Our management realized many years ago that the best possible chemical products and control systems will not produce the desired results without experienced, expert field support for our customers. Field application of our water management programs is the responsibility of experienced District Managers, supported by local field service technicians, our manufacturing plant people, and the central technical group and laboratory based at our Brockway headquarters.

Our District managers and central technical group have an average experience level of 25+ years in the water management field.

As we manufacture both chemicals and equipment, as well as provide complete cooling systems, our field people and customers are supported by a technical and manufacturing staff which is well equipped to respond to any type of equipment related problem. Both the Apache Junction and Brockway plants can provide direct customer services such as pump rebuilding, equipment installation, and electrical panel repair. No other supplier of cooling tower water management programs has such a depth of support for the field people.



PCT Supplied Cooling Tower System – Steel Mill

Technical Expertise

Our firm participates in the Association of Water Technologists “Certified Water Technologist (CWT)” program, which is the only legally accepted measure of expertise in the water management field. We are proud that three of our employees have obtained the CWT accreditation. In addition to the CWT program, several of our employees are state registered professional engineers (PE), while many hold various state water and wastewater treatment plant operator’s licenses. Our active research and development program and many technical developments in cooling tower water management have been documented by an average of two technical papers per year and the several patents pending.

Chemical Product Quality

Unlike many water management firms who purchase their products from generic toll blenders, ProChemTech devises, formulates, and manufactures its entire cooling water treatment product line at its two chemical manufacturing plants. Knowing that correct product chemistry is the base of a successful water management program, we manufacture our products to ensure that they will perform exactly as specified and have the correct chemical content for the program as designed. In addition, self manufacture maintains the security of our proprietary technologies and permits greater control of product manufacturing costs. Both of our chemical manufacturing plants are licensed by the USEPA for biocide production, sites 58616-1-AZ and 58616-1-PA. Biocide products are both state and USEPA registered.

ProChemTech International, Inc.

Apache Junction, AZ and Brockway, PA

“The Water Management Company”

814-265-0959

www.prochemtech.com