Zero Blowdown Technology (ZBT) for Cooling Towers
A "Green" Technology for Water Use Reduction

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Background

Evaporative cooling towers are very popular as they provide the most cost effective cooling technology for commercial air conditioning and industrial processes. This efficiency comes at a price however as about 80% of the incoming heat load is removed by water evaporation. As the cooling water evaporates, removing heat from the system, the dissolved solids present in makeup water, added to replace the evaporated water and maintain the water level in the cooling tower, become more concentrated. At some point, the dissolved materials exceed their solubility limit, which results in precipitation and formation of undesirable scale, typically calcium carbonate. While scale inhibitors, and sometimes acid, are added to the cooling water to increase the amount of dissolved solids that can be held in solution, at some point some water has to be intentionally drained from the cooling tower to keep the buildup of dissolved solids to levels below the solubility limit. The water drained from the cooling tower to control buildup of scale forming dissolved solids is termed **blowdown.** A convenient way to express the amount of dissolved solids buildup in a cooling tower is **cycles of concentration (COC),** which is simply the dissolved solids in the cooling water divided by the dissolved solids in the makeup water.

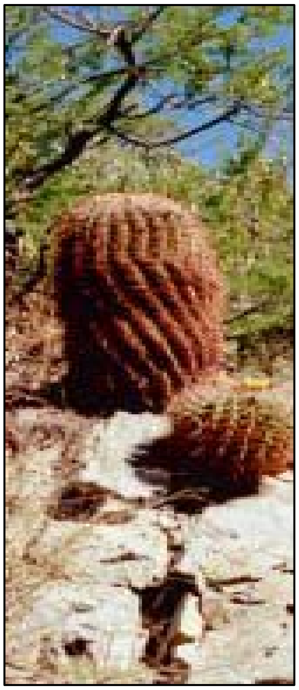
Cooling tower water is treated with a variety of scale, corrosion, and biological control (biocide) control chemicals to protect the system from corrosion, prevent scale, control deposition, and minimize microorganism growth in the cooling water. As a result, cooling tower blowdown has both a high dissolved solids content and often contains substantial amounts of toxic materials, primarily biocides. The high dissolved solids and biocide content of cooling tower blowdown create an adverse environmental impact when discharged to the public sewers or surface waters. In addition, environmental restrictions on discharge of some corrosion inhibitors, such as phosphate, zinc, and molybdate; and various biocides, such as carbamate and isothiazolin; have resulted in restrictive limits on the amount of cooling tower blowdown that can be discharged.

Cooling tower blowdown thus constitutes the major environmental impact from cooling tower system operation as it is "wasted" water, water run to sewers that must be replaced with fresh water. For instance, a 1000 ton rated cooling tower running at twice the makeup dissolved solids level (COC = 2) will evaporate 26,550 gallons per day (gpd) with a blowdown of 26,550 gpd. If the dissolved solids concentration is increased to four times (COC = 4) the makeup water level, the blowdown would be reduced to 8,867 gpd. The equations are:

$$\text{evaporation} = \text{tons cooling} \times 26.55 \text{ gpd} \qquad\qquad \text{blowdown} = \text{evaporation/COC-1}$$

With current water treatment technology, cooling towers can generally be operated at maximum COC values between 2 and 8, based on the makeup water quality and chemical treatment program used due to a combination of scale, corrosion, and deposition problems if these values are exceeded.

Reducing Water Usage



Due to a combination of drought conditions, lack of infrastructure, and constantly increasing demand for fresh water supplies; many areas of the country are experiencing water shortages. In these situations where fresh water is in short supply, it is desirable to eliminate cooling tower blowdown to conserve as much water as possible.

Elimination of cooling tower blowdown also eliminates the potential environmental problems resulting from discharge of blowdown to the public sewers or to stream.

Another driver towards elimination of cooling tower blowdown is the United States Green Building Council (USGBC) building certification plan for retrofitted and new buildings, Leadership in Energy and Environmental Design (LEED). The LEED certification program awards "points" for building features that improve energy usage and reducing the environmental impact of building operation. Elimination of cooling tower blowdown provides LEED points due to reduced water use, innovative technology, and lessened environmental impact due to no discharge of toxic chemicals.

Basic Technology

A small amount of water is lost from an operating cooling tower in the air stream passing through the unit; this is commonly termed "**windage**", or "**drift**", and varies from 0.01% to 0.3% of the cooling water recirculation rate. At some point, as COC are increased, the amount of windage will equal the blowdown rate and the cooling tower goes into zero blowdown operation. Of course, some means is required to prevent scale formation as COC are increased.

A proven technology, which addresses the need for zero blowdown operation while avoiding scale problems, is to soften (cation exchange) the makeup water, removing the scale forming ions prior to use. However, problems resulting from high COC operation with softened makeup water include the substantial **increase in corrosivity of highly cycled soft water, formation of "white rust", deposition, biological control, and system chemistry control.**

ZBT History

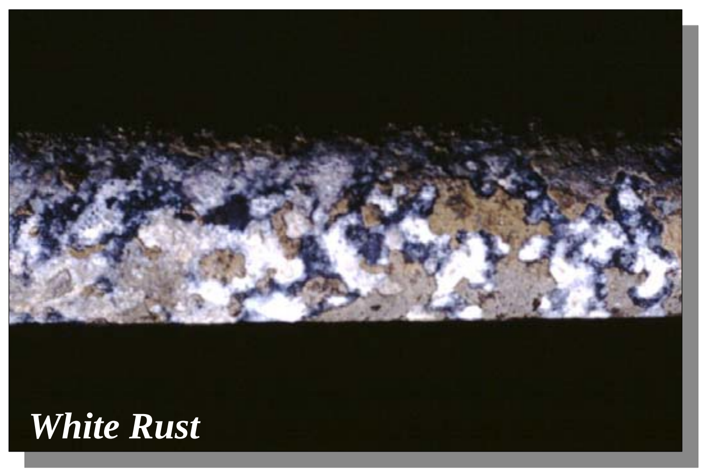
Operation of cooling towers with softened makeup water was started in 1984 at Brockway Glass Company in a successful program, directed by Timothy Keister, to control scale in extremely high heat flux furnace electrode cooling jackets. ProChemTech International has further developed and refined this ground breaking technology into a complete water management technology which addresses the need for increased COC while maintaining control of corrosion, scale, and deposition at a reasonable cost. In 1992 the first successful ZBT installation on twelve cooling tower systems at a large metal forging operation in Pennsylvania was implemented due to environmental reasons. The plant subsequently operated with zero blowdown for over five years. Research into the many problems resultant from zero blowdown has been continued to the present and has been so successful that two patents, US 7,595,000 and 8,128,841, have been issued covering the process and chemical corrosion inhibitor composition.

The benefits of this proven soft water makeup technology are immediately obvious for facilities that need to drastically reduce water use in an economic, environmentally sound manner, **blowdown can be eliminated.** Use of softened water immediately eliminates the scale potential of the cooling water, rendering it non-scale forming. With elimination of scale formation potential, the cooling water COC can be increased to the point where windage equals the blowdown rate needed to maintain a constant COC value, usually between 12 and 25, at which point the cooling tower is operating with zero blowdown.

Corrosion

Highly cycled soft water is much more corrosive than naturally soft water, or hard water; and the water management program must provide superior corrosion control chemistry. ProChemTech has developed a specific chemistry that controls corrosion of ferrous, galvanize, aluminum, and yellow metals in a highly concentrated soft water environment. The corrosion control chemistry is based upon polysilicates working in combination with inorganic/organic inhibitors, and advanced polymers. Cooling towers using soft water makeup and ProChemTech chemical products routinely obtain steel corrosion rates well below 2 mil/yr, rates between 0.25 and 0.5 mil/yr are very common. This performance, with cycled soft water, exceeds that which can be achieved using conventional technology with hard water makeup. Typical yellow metal corrosion rates are below 0.2 mil/yr with levels in the area of 0.1 to 0.02 mil/yr being common.

"White Rust", an accelerated corrosion of zinc (galvanize), and its alloys, due to chemical attack by high pH/high alkalinity waters (highly cycled soft water), is a major problem with high COC operation of cooling systems. Softening hard water actually makes the problem worse; replacing hardness ions with sodium makes the water substantially more reactive towards zinc and its alloys. Our discovery, in 1995, of an organic filming type chemical inhibitor to control white rust, trademarked **"ZincGard",** permits zero blowdown operation with highly cycled softened makeup waters in galvanized cooling towers. ZincGard is a component of our chemical products used where galvanized components are present in the cooling system.



White Rust

Deposition

Operation of many cooling systems, using softened makeup water since 1984, has demonstrated operation at COC from six (6) to ten (10) is optimum for control of deposition via dispersants and blowdown. As zero blowdown requires operation at COC values ranging from 12 to 25, or more, the issue of deposition control has to be addressed.

We routinely utilize multimedia pressure filters, operated in a side stream mode, to remove the suspended solids that cause deposition from the cooling water by filtration. These automatic backwashing units are designed to turnover the volume of cooling water in the cooling tower in 12 to 24 hours.

Biological Control

We have found that use of a single oxidizing biocide is sufficient to establish excellent control of microorganisms in almost all cooling tower systems. Since highly cycled soft water is generally also high pH, about 8.0 and as high as 9.5, the oxidizing biocide of choice is bromine.

ElectroBrom Unit

Our preferred method of bromine delivery, due to low operating cost and the complete absence of hazardous materials, is electrolytic bromine. We have developed three electrolytic bromine generators; the SSBrom is a side stream unit which requires no chemical feed and is suitable for systems up to 75,000 gallons in volume. The MiniBrom and ElectroBrom generators utilize a concentrated feed stream for electrolysis and can be specified to handle any size cooling tower system up to 2,000 MW power stations. The SSBrom unit is particularly well suited for “green” installations due to lack of a specific chemical feed, it uses bromide ions present in the highly concentrated cooling water for production of electrolytic bromine. In the event that capital cost must be minimized, our liquid stabilized bromine, PCT 3026 can often be utilized in existing chemical control and feed equipment.

System Control

As cooling systems operated with ZBT have no blowdown, the common “bleed-feed” control method of adding inhibitors based on blowdown will not work. In a ZBT cooling system, either the makeup proportional method or a direct measurement technique, such as our patented BlueTrak, must be employed to control inhibitor feed. .

Integrated Supplier

ZBT requires several specific items for successful implementation:

- makeup water softener
- side stream filtration
- effective microorganism control
- corrosion inhibition chemistry specific for highly cycled soft water
- effective chemical inhibitor feed control

ProChemTech International is the only supplier with the experience and capability to supply all the components for a successful ZBT cooling system.

ProChemTech International, Inc.

“Innovation in Water Management”

Apache Junction, AZ, and Brockway, PA

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