ENGINEERING WHITE PAPER

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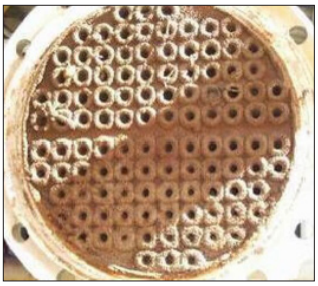
Cooling Tower Water Treatment

Evaporative cooling is the most energy efficient cooling method, but it also requires a high degree of maintenance in addition to water consumption. The most common problem with evaporative equipment is poor water treatment. By offering effective and easy water treatment much of that maintenance downside of evaporative cooling can be minimized.

Water treatment must manage three problems: scale, corrosion, and biological growth. This paper will discuss the causes of these problems and two solutions: chemical water treatment or chemical-free treatment systems.

Scale

Scale is hard mineral deposits that stick to a surface. Scale is highly insulating, a layer only 0.05 inches thick can cause a 45% drop in equipment efficiency. The most common form of scale is calcium limescale.



Scale inside a water-cooled chiller condenser

Biological growth on cooling tower inlet louvers

When water evaporates inside a cooling tower it leaves behind dissolved minerals. More water is added to replace what evaporated, carrying more minerals into the tower. This increases the concentration of minerals in the water over time. There is a limit to the concentration of each mineral that water can hold, called saturation, and when this limit is exceeded the minerals will form scale. Scale forms on hot surfaces first, so chiller tubes or heat exchangers can be fouled with scale even when no scale is visible on the cooling tower.

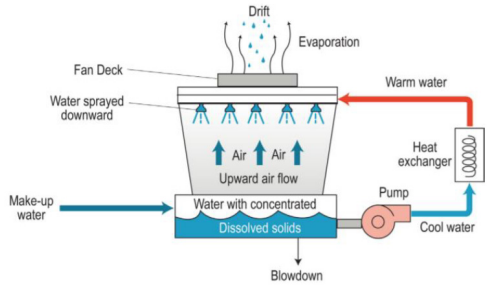
The first tool in managing scale is bleed or blowdown, which is water drained from the tower into the sewer system. Bleed water carries minerals out of the tower and is replaced by makeup water with a lower concentration of minerals. The makeup water dilutes the water in the tower, lowering the overall concentration of dissolved minerals.

While bleed or blowdown are effective at preventing scale, they are also expensive. Every gallon of bleed water is replaced by a gallon of makeup water, incurring water and sewer charges. Owners therefore want to minimize the amount of water they waste as bleed.

The rate of water blowdown is often measured in cycles of concentration. One cycle of concentration means that the mineral concentration has doubled from the concentration in the supply water, two cycles of concentration means the mineral concentration is triple the supply water, and so on. At 3 cycles, 75% of the water entering the tower is evaporated and 25% is bled to the sewer. At 9 cycles, only 10% is bled to the sewer. Increasing the cycles of concentration therefore translates to significant water savings for the owner.

Biological Growth

Cooling towers are a friendly environment for bacteria. Water typically enters the tower at 90-100°F, keeping the tower environment warm. Airflow through the tower introduces pollen, leaves, and dust, providing nutrients to bacteria. Most tower designs allow sunlight into the basin, fueling bacterial growth.



Water flow in a cooling tower, showing Blowdown and Makeup connections

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Bacterial growth is a health hazard. Legionella bacteria grow in cooling tower water and are spread in the tower exhaust air. Breathing contaminated air causes Legionnaires Disease, which can be fatal.

Biological growth also impacts the efficiency of cooling equipment. Algae and bacteria form an insulating substance called biofilm. Biofilm is approximately 5 times more insulating than scale, so small layers have a dramatic impact on energy efficiency.

When thinking of bacteria, remember that they "eat, breed and defecate". Bacteria feed on sunlight and nutrients in the water and can be starved by removing these. Bacteria reproduce constantly and bacteria levels will explode if not controlled. Finally, bacteria produce biofilm and acid waste, harming equipment.

Corrosion

Corrosion is chemical reactions that destroy the material of a cooling tower or other equipment on the tower water loop. Most corrosion is caused by poor use of chemical water treatment or salty air in coastal areas. Stainless Steel or polymer coated materials will resist corrosion far better than Galvanized Steel.

Galvanized Steel is the most common tower material and required a special process called passivation. Galvanized Steel is coated with a layer of Zinc for protection. The Zinc reacts with the tower water in the first few months after installation and forms a non-reactive layer of Zinc oxide. During this process special attention must be paid to the water chemistry to prevent corrosion of the Zinc, also called White Rust.

Bacterial growth can lead to corrosion even when the water chemistry is not corrosive. Bacteria produce acid waste that corrodes surfaces where the bacteria grow.

Chemical Water Treatment

Most cooling tower water treatment uses three chemicals, one each to manage scale, biological growth and corrosion. Scale inhibitors change the chemistry of the water to increase the amount of dissolved calcium it can hold. Biocides are toxic chemicals used to control bacterial growth. Since most scale inhibitors and biocides are corrosive, a corrosion inhibitor is added to protect the equipment.

Chemical treatment can be effective, but it has significant downsides. Since bleed or blowdown water carries chemicals out of the tower, the owner must constantly add more chemicals. This is a significant expense and headache for the owner. The chemicals used harm the environment and may require sewer discharge permits. Exposure to corrosive and toxic chemicals is a health risk for maintenance staff.

Most chemical treatment providers use a business model where they install equipment at no cost to the owner, then charge for the chemicals. The provider loses money on the install, then makes it up by charging for chemicals. This can create a cycle of "feed and bleed", adding more chemicals than needed only to bleed them out to the sewer.

Some systems add salt to cooling tower water to prevent scale and biological growth. The water chemistry produced by these systems is outside the recommendations of mainstream cooling tower manufacturers and may void equipment warranties. When improperly managed these systems can result in high corrosion rates.

Chemical Free Water Treatment

Many chemical free water treatment systems have been developed, but the most successful all use an electric signal in the water. The electric signal has several effects that control scale and biological growth.

Calcium dissolved in water has an electric charge, which causes calcium atoms to repel each other. Because the calcium atoms repel each other they cannot clump together, instead when the calcium concentration gets too high they attach to surfaces. The electric signal overcomes the force that keeps the calcium atoms apart, letting them clump together in the water. The calcium then falls out of the water as a white sand.

Because calcium is removed from the water, it no longer limits the cycles of concentration. Chemical free systems often operate at higher cycles of concentration than chemical systems, saving money on water.

When calcium clumps together in the water it tends to form a shell around bacteria. This process of encapsulation cuts bacteria off from nutrients in the water and causes them to fall out of the water stream. The electric pulse also harms bacteria by creating holes in the cell wall. This process is called electroporation.

Ultraviolet light can be used to help control bacteria, but it can only kill bacteria that "see" the light. If the water

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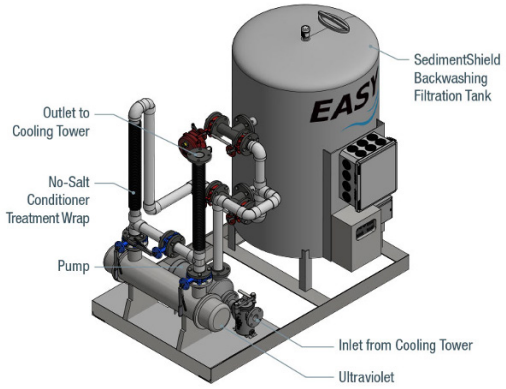


The Easy Water CTF cooling tower water treatment system

is cloudy due to dirt or dissolved minerals ultraviolet light will not be effective. Effective filtration is therefore necessary with ultraviolet treatment.

Because these systems do not use harsh chemicals, they do not cause corrosion. However, passivation of galvanized steel equipment still requires special attention to prevent white rust.

Air Reps partners with Easy Water to offer a chemical free water treatment system. This system comes on a packaged skid with onboard pumps. It contains an electric treatment device, ultraviolet light, and a high efficiency sub-micron filter. Combining these three proven technologies in a packaged system offers the best available treatment in a form that is convenient and easy to install.

Other Factors in Water Treatment

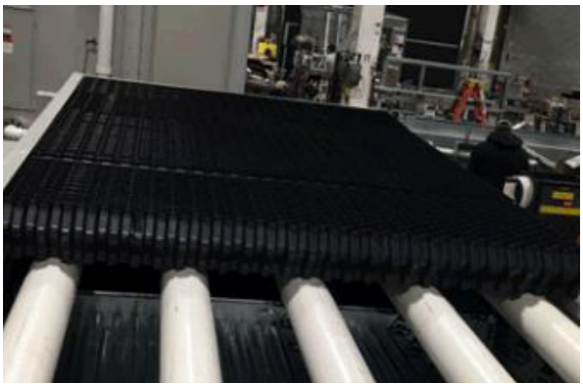
When a customer complains of water problems it is important to evaluate the whole tower system. While water treatment offers effective tools to manage problems, we also have tools to address the root causes.

Air Filtration: Bacteria require nutrients to live, and nutrients enter the cooling tower through the air. A cooling tower washes the air that flows through it, pulling pollen, dust, and leaves into the water. Inlet screens remove these materials from the air, preventing bacteria growth. Owners should take care to clean screens often and use screens designed specifically for cooling towers.

Tower Location: Ideally, cooling tower inlets should be located away from plants or building exhaust. While this is often out of our control, tower location should be discussed when installing new equipment.

Water Filtration: Filtration or centrifugal separators removes nutrients from the water, starving bacteria. Sub-micron filtration systems will also remove bacteria from the water. Filtration systems can include sump sweeper piping, which uses water flow in the tower to push debris toward the filter inlet.

Sunlight: Some bacteria gain energy from sunlight, and most tower designs allow sunlight to enter the tower. Using inlet shields that block sunlight will reduce biological growth.



BAC combined inlet shields, designed to block light and debris

Lakos centrifugal separators

Water Monitoring

Any water treatment system requires periodic water testing and adjustment. For chemical water treatment these visits will also include restocking the chemicals. Most manufacturers recommend monthly testing. Testing will measure pH (acidity), mineral concentrations in the water, and bacteria counts. The blowdown or bleed rate will be adjusted based on the mineral concentrations. Constant adjustment is necessary as mineral concentrations in the supply water vary seasonally. If bacteria counts are high, corrective action must be taken. This may take the form of shocking the system with an aggressive biocide, or for chemical free systems it may trigger troubleshooting of the system.

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