



Microbiological Control Strategy in Cooling Tower Systems

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Because evaporative cooling tower systems are open to the atmosphere and sunlight, they are prone to microbiological (MB) activity and the resulting adverse affects. Pathogenic microbes such as *Legionella pneumophila* can create health concerns. Slime created by the commonly occurring gram-negative type of organisms can lead to heat exchanger fouling and loss of cooling efficiency. The biofilm can also lead to microbiologically influenced corrosion (MIC) and severe localized metal loss. Algae and fungal mats can impede water flow, cause an unsightly appearance, and damage wood and tower structures.

Good quality makeup water such as municipally supplied drinking water or well water should have negligible microbes and nutrients to support biological growth. Cooling towers, however, take in air-borne dust and microbes. The dust contains nutrients to support the growth of microorganisms. When there is minimal contamination, the activity level can become self-limiting and manageable.

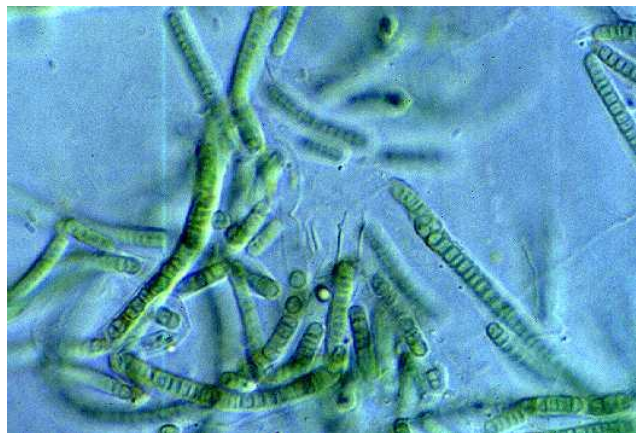
The location of the cooling tower and the processes near the cooling tower can greatly affect the propensity for MB activity. Food plants, for example, can contribute plenty of organic compounds for the bacteria to have accelerated growth. Oils that contaminate a cooling water contribute to high MB growth. Process contaminations or the use of secondary wastewaters for makeup to the cooling towers improves the environment for MB growth. Phosphates in the water can increase algae

growth and then algae can feed bacteria. The higher the biochemical oxygen demand (BOD) or total organic carbon (TOC) concentration of the cooling water, the greater the risk for increased biological fouling.

There is no single solution to microbiological control in cooling systems.

The treatment choice depends upon such things as:

- Water chemistry
- pH
- Types of organisms to control
- Compatibility with corrosion and scale inhibitor treatment chemicals
- System volume
- Retention time
- Temperature
- System design
- Materials of construction
- Discharge points and permits
- Personal preferences
- Cost limitations



The primary chemical treatment options include:

- Oxidizing biocides
- Nonoxidizing biocides

- Surfactants, biodispersants, biopenetrants

Oxidizing Biocides

Oxidizing biocides include those chemicals that have the ability to kill microorganisms through an electrochemical process of oxidation. The oxidizing agent such as chlorine gains electrons in the process while the substance becoming oxidized loses electrons.

Depending upon the oxidizer being used, a new compound is created and in the case of microorganisms, some life function is changed that causes the organism to die or at least to not proliferate.

Some oxidizing biocides used in cooling tower systems include:

- Chlorine
- Bromine
- Iodine
- Chlorine dioxide
- Ozone
- Hydrogen peroxide

There are differences based upon how they are introduced into the water, how they react with water, how they react with various compounds found in the water, their stability, their oxidizing power, their ability to penetrate biofilms, and their effectiveness.

Nonoxidizing Biocides

This class of chemicals works through various poisoning processes such as interfering with reproduction, stopping respiration, or lysing the cell wall. They are generally shot fed to achieve a high enough concentration for a long enough period of time to kill the bacteria, algae, or fungi. Kill time generally requires several hours up to a day.

Some nonoxidizing biocides include:

- Isothiazolines
- 2,2 Dibromo-3-nitropropionamide (DBNPA)
- Carbamates
- Gluteraldehyde
- Methylene bithiocyanate (MBT)
- Polyquaternary amines
- Tetrahydro-3,5, dimethyl-2H-1,3,5 thiazine-2-thione
- 2-(tert-butylamino)-4-chloro-6-(ethylamino)-S-triazine

Selection of a nonoxidizing biocide depends upon water pH, available retention time, efficacy against various bacteria, fungus, and algae, biodegradability, toxicity, and compatibility with the other chemistry.

Biodispersants / Biopenetrants

Chemicals that can penetrate and loosen the complex matrix of biofilms allow biocides to reach the organisms for more effective kill and control. These chemicals are typically shot fed at dosages that break down polysaccharides, emulsify oils, release minerals and foulants, or disperse the biopolymers.

Some biopenetrants or biodispersants include:

- DTEA II (2-Decylthio ethanamine)
- DMAD (Fatty acid amide)
- Dodecylamine acetate
- Polyquaternary amines
- DOSS (Dioctylsulfosuccinate)
- Polyoxyalkylenes
- Enzymes

The Formation of Biofilms

The ultimate objective of a biocide is to prevent biofilms (sessile bacteria) from forming and to limit the existence of pathogens. Assuming the

cooling system is free of bacteria and biofilms, how do they become established?

1. Bacteria are introduced into the cooling water system from the air, the makeup water, or a process contamination.
2. The bacteria are initially planktonic or free-swimming.
3. They migrate to an area where they attach themselves to a surface and begin multiplying and creating a biofilm.
4. The biofilm continues to grow until some of it sloughs off and migrates to another area where it becomes attached and creates another biofilm area.



Continuous or Intermittent Biocide Feed

Oxidizing biocides such as chlorine can be fed continuously or intermittently. If it is fed continuously, it is always available to oxidize and kill planktonic bacteria before they can migrate to surfaces and create a biofilm as long as the bacteria are exposed. Continuous feed and residual of normally low oxidant levels can therefore be a very effective means of preventing the formation of biofilms.

Planktonic bacteria are more easily penetrated by a biocide and killed than bacteria that are protected by the biomass in surface slime. There must be sufficiently high enough levels of the oxidant to oxidize any biofilm that may have formed. Dirt and foulants in a system can offer protection to bacteria from the biocide and allow

for the formation of biofilms under the accumulations of sludge.

If an oxidizing biocide is fed intermittently, the strategy is to feed it frequently enough and often enough that planktonic bacteria are killed. It also must be fed while any biofilm formation has been minimal enough that the intermittent dosage can still penetrate and kill the bacteria contained in the early stages of its development and oxidize the biofilm.

Chlorine has shown to be effective at controlling *Legionella* bacteria and is applied at higher dosages when Legionnaires' disease has been detected or bacteria levels are found to be high.



One Suggested Treatment Approach

One effective treatment strategy is the application of continuous chlorination or if the situation permits it, intermittent feed of chlorine to achieve a free chlorine residual.

Sources of chlorine can be gaseous chlorine, but because of safety concerns and reporting requirements, a liquid sodium hypochlorite solution of 12.5% activity (12% as chlorine) is commonly used. Other sources of chlorine can be di- or tri- chloroisocyanates. These are more expensive, but the cyanuric acid stabilizes the chlorine in the water and slows the degradation that occurs from the sunlight. Calcium hypochlorite can also be used, but it adds calcium and scaling potential to the water. Liquid

sodium hypochlorite is commonly the most cost effective source for the chlorine.

Depending upon the cooling system, food source, and biological activity, the chlorine would frequently be supplemented with continuous or intermittent biocides or biopenetrant feed, along with a nonoxidizing biocide as needed.

Chlorine ionizes and is in the water as hypochlorous acid (HOCl) and hypochlorite ion (OCl⁻). The hypochlorous acid is the stronger oxidizer and it is able to penetrate bacteria cell walls better. As the pH rises above the 7.5 – 8.0 range, the hypochlorite ion dominates and there is an argument against the effectiveness of chlorine at alkaline conditions.

Hypochlorite is still a strong oxidizer and able to oxidize biofilms. There is also the phenomenon of the reservoir effect. The ratio of the hypochlorous acid to hypochlorite ion is fixed for a given pH, so if the hypochlorous is used to kill bacteria, available hypochlorite shifts to become hypochlorous acid, all ready to do some more active killing.

Strategies for High pH

- Carry higher levels of free chlorine as long as corrosion control can still be managed.
- Feed sodium bromide or bromochlorodimethylhydantoin (BCDMH) and revert to bromine chemistry since its dissociation curve is shifted to the right. At high pH its hypobromous acid concentration is higher when compared to HOCl.

- Bromine also has the advantage that its combined bromine molecules are more effective biocides than combined chlorine compounds. In high oxidation demand waters or waters high in ammonium compounds, bromine may be more effective and free halogen residuals may not be needed.
- Feed additional nonoxidizing biocide and/or biopenetrants.
- Look at other oxidants such as chlorine dioxide that is more pH independent, or ozone, which is a stronger oxidant.

Conclusion

There are many things that must be considered when developing an effective biological control program. A process of trial and error may be needed to find what works best for your system. One cost effective strategy is to apply chlorine either continuously or intermittently to obtain a free chlorine residual since it is an accepted *Legionella* biocide, and it is usually cost effective for bacteria and algae control. Depending upon pH, it may be beneficial to convert to bromine chemistry. The supplemental use of biocides / biopenetrants and a nonoxidizing biocide will improve results and help kill the broad spectrum of microbiological activity found in cooling tower systems.



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