WATERTALK

Volume 14, Issue 1 *February 2014*

MICROBIOLOGICAL GROWTH IN OPEN RECIRCULATING COOLING WATER SYSTEMS

Biological fouling of open recirculating cooling water systems results from the development and excessive growth of three of the simplest forms of plant life – algae, fungi, and bacteria. Each of these microorganisms is uniquely different from the other and will develop in different locations within the cooling water system.

Algae is the plural of the Latin word for seaweed, and it is most familiar as a green scum or a thread-like, stringy mass. Algae contain chlorophyll and uses photosynthesis to produce food. Since algae must have light, it will not grow inside pipes, heat exchangers or covered storage tanks. More than 30,000 species of algae have been described ranging in size from unicellular microscopic forms to others more than 100 feet long. Algae are classified into five principal groups based upon their color. In many cases, they contain pigments which impart a characteristic color to the organism. These colors are green, blue-green, brown, red, or yellow.

Fungi include all simple plants not containing chlorophyll. Simplest fungi are bacteria. Most advanced forms are yeasts and molds with the highest life forms including mushrooms, rusts, and smuts. All fungi require moisture for growth, but only the simplest forms, such as bacteria, will live under water. Many types of fungi will live outside of a water environment and require oxygen for growth. In industrial cooling water systems, fungal growths may be encountered above the tower basin waterline. Wooden cooling towers are subject to attack by cellulose consuming fungi.

The smallest, yet most troublesome fungi in cooling water systems are bacteria. Bacteria will grow in any water system containing organic matter. Some bacteria need oxygen and are referred to as aerobic. Others prosper without oxygen and are call anaerobic. Some will oxidize sulfur or sulfites to sulfuric acid, and others reduce sulfate to sulfides or use iron for their growth.

Microbiological growths in cooling towers, heat exchangers, and recirculating lines can cause problems for personnel responsible for the operation and maintenance of cooling systems. Large masses of algae sloughing off of cooling tower fill, walls, or basin can plug screens and restrict flow in pipe lines, heat exchangers, and pumps. Algae will inhibit the evaporative cooling process by restricting air flow through the cooling tower and causing channeling of the water through the fill.

Algae, biofilms, and anaerobic bacteria all work to increase the corrosion rate of metal waterside surfaces. When adhering to metal surfaces, algae and biofilms accelerate pitting corrosion by the depolarizing action of oxygen released during their metabolic processes. Local cell action caused by accumulation of dead algae lodged in heat exchanger tubes and tube sheet can cause pitting and gouging of metals.

Bacteria are typically found in both the recirculating cooling water and on system component surfaces. These microorganisms are attached to surfaces by proteinaceous appendages called fimbriae. When several fimbriae have glued the cell to the surface, a tenacious slime is formed. This slime or biofilm is difficult to break up.

Bacteria caused corrosion occurs at the interface between the metal component of the cooling system and the biofilm. There is evidence indicating that bacterial corrosion involves a number of species all acting at one time. Some organisms are directly involved in the corrosion mechanism, while others play only a supporting but equally important role.

Sulfate-reducing bacteria usually are not found in aerated water since oxygen is their enemy. A layer of biofilm on a metal pipe that excludes oxygen will foster the growth of sulfate-reducing bacteria and support corrosion. Silt, sediment, and debris in the basin of galvanized or stainless steel cooling towers provide an anaerobic environment suitable for the corrosive action of sulfate reducers. This can result in large holes forming in the floor of a metal cooling tower basin.

The bacterium normally associated with microbial corrosion is Desulfovibrio desulfuricans. This is anaerobic bacteria, which is ever present in cooling tower systems. By an electrochemical process called cathodic depolarization, the bacteria will remove oxygen from the sulfate ion and release sulfide ion as a waste product. The highly reactive sulfide ion will attack metal components in the cooling water system.

The biochemical reaction is as follows:

$4Fe + SO_4^{-2} + 4H_2O + \text{bacteria} = 3\ Fe\ (OH)_2 + Fe\ S + 2\ OH^-$

As can be seen, a new metal cooling tower can quickly be converted to rust and iron sulfide.

In addition to the destructive effect of bacterial biofilms, they can harbor pathogenic bacteria like Legionella pneumophila. Legionnaire's disease is caused by the Legionella bacterium. Amoebae living under biofilms act as a host for the proliferation of Legionella bacterium.

Biological growth can be inhibited using microbiocides. These chemical agents will either kill or inhibit the growth of microorganisms and prevent the formation of biofilms. Contemporary microbiocides are "broad spectrum," exhibiting biotoxic properties against various microorganisms commonly found in cooling water systems. Many of the microbiocides will degrade to non-toxic by-products in a reasonable period of time after leaving the cooling tower. Other microbiocides become biodegradable after dilution below the toxic concentration. The effective use of a microbiocide is essential to maintaining an efficient, open recirculating cooling water system.

* * * * * * * * * * * *

TABLE - Microorganisms commonly occurring in cooling water.

TYPE	TECHNICAL NAME(S)	SHAPE	pH AND TEMPERATURE RANGE	AIR AND LIGHT REQUIREMENTS	PROBLEMS ENCOUNTERED
1. Algae	Chlorella Ulothrix Oscillatoria	Single cell or thread-like	5.5 to 9.5 60 to 130 F	Require air (aerobes) and light for growth.	Green and blue-green slimy growths in lighted areas. Interfere with water distribution, heat transfer, and may accelerate corrosion.
2. Bacteria	Aerobacter Pseudomonas Bacillus	Spheres and rods occurring singly or in chains	5 to 9 60 to 150 F	Most require air (aerobes) for growth. However, there are some that cannot tolerate any air (anerobes). Do not require light.	Slime masses due to capsule or waste materials can plug heat exchangers, reduce heat transfer efficiency, accelerate corrosion, and cause build-up of foulants. Color of slime mass is usually gray-brown.
3. Sulfate-Reducing Bacteria	Desulfovibrio	Single rods straight or curved	5.5 to 8.5 77 to 140 F	Generally, cannot tolerate air. Do not require light to grow.	Black insoluble ferrous sulfide deposits plug heat exchangers And accelerate corrosion. Capable of generating large Quantities of hydrogen sulfide.