Advanced Biofilm Accumulation Device

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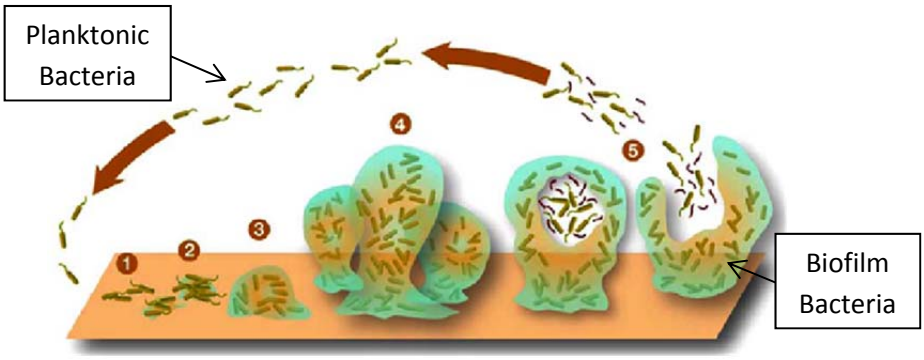


Above: Biofilm Cycle

Insight:

The above diagram shows the biofilm cycle. Biofilm (sessile) is an attached microbiological, while planktonic travels in the water. As the cycle shows, the planktonic bacteria are released from the biofilm and journey throughout the system. Later at the peak of their growth cycle, they will attach to a surface to become a biofilm. The biofilm grows and reproduces more planktonic bacteria inside of its protective layer. When biofilm matures, it releases more planktonic bacteria, and the colony expands. This cycle repeats itself over and over.

Biofilms are more resistant to drugs and chemicals that are designed to exterminate them than the planktonic species. Biofilms and planktonic microbiological organisms have two different growth cycles. For proper extermination, it is prudent to focus on the biofilm growth cycle for eradication, hence controlling the planktonic bacteria.

Biofilm:

Biofilm naturally grows just about anywhere there is moisture. Apply heat and a food source, and they will flourish. Yellowstone National Park is a very good example for having biofilm pools with the hot springs. Microbes simply grow on natural or manmade surfaces. Bacteria are doing what comes naturally to them when they attach to industrial surfaces. This causes problems for nearly all industrial and commercial water applications. These applications are cooling towers, chillers, boilers, and domestic/industrial hot water systems.

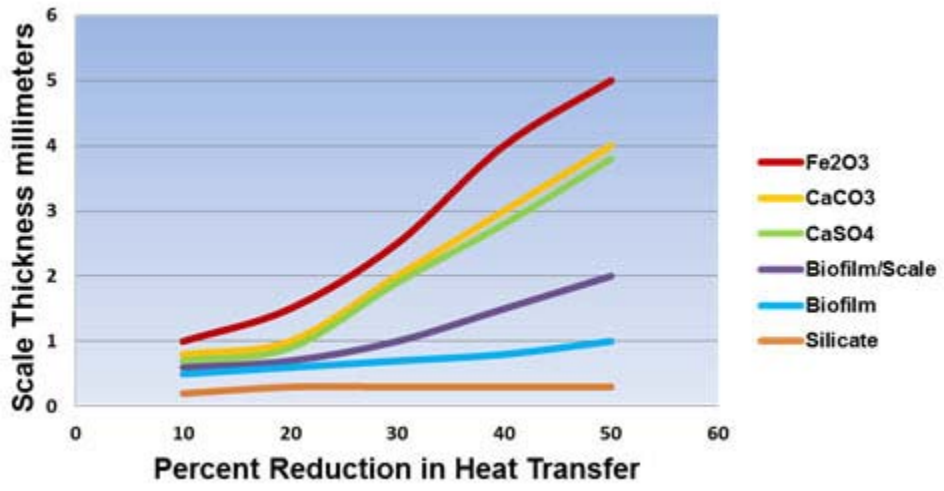
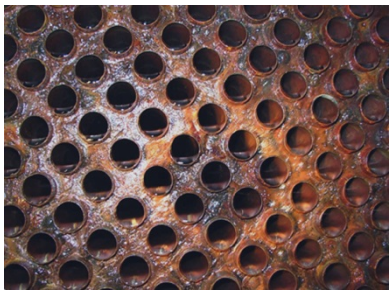


Figure 1

Cost:

Biofilm is the second greatest insulator as shown above in Figure 1. In the book Biofilms, by Alfred B. Cunningham, John E. Lennox, and Rockford J. Ross, it is written in Chapter 5 that biofilms cause the loss of literally billions of dollars in treatment and lost production.[1] Montana State University is the Center for Biofilm Engineering, and claims that bio-fouling and bio-corrosion are constant and expensive issues costing billions of dollars in the United States.

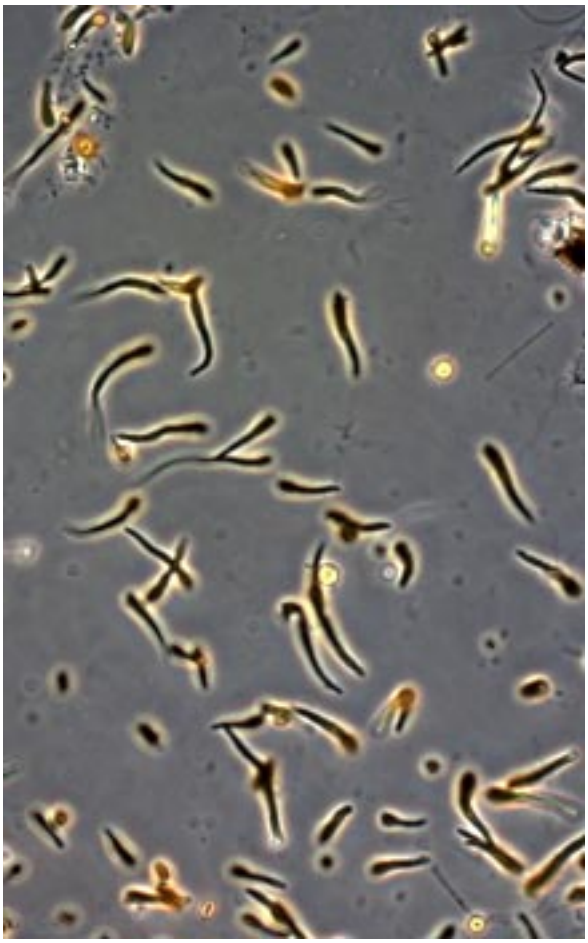
Biofilm has four times greater the insulating properties than calcium carbonate scale at equal thicknesses.[2] This creates severe thermal transfer loss equating into increased energy use. The California Society for Healthcare Engineering (CSHE) reported astonishing results showing a layer of biofilm measuring just 150 microns (.006 thousandths of an inch) in thickness results in a 5.3% increase in energy consumption with cooling tower systems. CSHE also validated that a biofilm colony which measures 900 microns (1/32 of an inch) in thickness will result in a 32.2% increase in energy use with cooling towers.[2] Microbiologically induced corrosion (MIC) creates localized corrosion or pitting. One mil per year (MPY) or one thousandth of an inch is an industry accepted corrosion standard. However, localized corrosion rates can be up to 100 times more with MIC.[3] It is written that 20% of all corrosion damage in fluid piping and systems is MIC influenced by microbiologicals.[4] Additionally, the biofilms that collect inside pipes and heat exchangers create tremendous resistance to recirculating water, and this friction resistance results in increased power consumption to operate recirculating pumps.[5]


Problem Areas:

Biofilm will accumulate in piping causing clogging and reduced flow. It also attaches to heat exchangers creating a tremendous increase in energy consumption due to its insulation ability. This insulation correlates to more energy consumption since the heat transfer is far less efficient. Biofilms promote localized corrosion that destroys pipes and heat exchangers. Biofilms consume phosphate based water treatment chemicals, a major water treatment element.

The Main Problem:



Above: Common cooling tower system biofilm.

Left Hand Side: Planktonic bacteria released from same biofilm.

Most people think the microorganisms in process water act the same. The above images clearly reveal different microorganisms once related to the original biofilm. These different organisms have a 56% difference in growth rate.[6] The water chemistry, turbidity of the water, temperature of the water, cleanliness of the system, and resistance to biocides all change. What never changes is the growth rate of these two organisms. Using this knowledge with a novel biofilm accumulation device dramatically increases the performance of microbiological eradication.

Biofilm Accumulation Device:

NASA, water treatment plants, pulp mills, offshore drilling rigs and oil pipelines, all do biofilm monitoring regularly. Unfortunately, most industrial and commercial buildings with cooling towers, chillers, and boilers do not. Cost is the main reason. The time and expense to tear equipment apart for swabbing or inspection can be tremendous.

Oxidation Reduction Potential (ORP), dip slide tests, and residual biocide measurements provides a great indication that conditions are trustworthy for preventing biological activity, but this does not confirm biofilm exists in water systems. Having this accumulation device allows:

- A superior biofilm accumulation device.
- Legionella Risk Management.
- Optimization of biocide control.
- Avoiding expensive biofilm electronic sensors that cannot differentiate from scale, iron oxide converting from the coagulant hydroxide form, or other fouling.
- Installing at logical biofilm formation sites.
- Mimicking the areas biofilms prefer growing on, such as flanges, gaskets, and diaphragms in pumps.
- Revealing fresh and new biofilm accumulation as it occurs with novel biofilm immediate capture material.
- An economical approach.

Monitoring biofilm and applying biocides before the dispersion stage, stops the reproduction of the microbiological cycle. Eliminating reproduction depletes the colony immensely with the biocide dosing, and turns the treatment into a proactive program instead of reactive to the dip slide and ATP results of planktonic dispersal from biofilm. Because of the 56% difference in growth rate, it is impossible to time dosing for biofilm that is necessary for planktonic control. When the test results are not quantifying the colony because of this growth rate[6], the proper timing for biocide dosing becomes a fool's errand.

This biofilm accumulation device helps with the new BSR/ASHRAE Standard 188 protocol for water treatment with Legionella guidelines.

Sources:

1. "Biofilm Formation and Growth - Biofilm Development." The Biofilms Hypertextbook. 2008. Montana State University Center for Biofilm Engineering, Web. 12 Jan 2010.

2. "Biofilm." Norahco International Technology. 2008. Norahco Technology International, Ltd., Web. 11 Jan 2010.

3. "Microbiological Fouling." AWT Technical Reference and Training Manual. 1st Edition. McLean, VA: Association of Water Technologies, 2002. Print.

4. Costerton, J.W. and J. Boivin. “Economics of microbial corrosion in water systems.” International Conference on Microbially influenced Corrosion, Paper No. 57. Knoxville, 1991.

5. Characklis, W.G., and K.E. Cooksey. "Biofilms and Microbial Fouling." Advances in Applied Microbiology. 29. (1983): 129. Print.

6. “A Method for Quantitative Determination of Biofilm Viability”, Ken Welch, Yanling Cai and Maria Strømme, Division for Nanotechnology and Functional Materials, Department of Engineering Sciences, The Ångström Laboratory, Uppsala University, Box 534, 75121 Uppsala, Sweden