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Biofilm

Biofilms are accumulations of microbial cells (algal, bacterial and fungal) and the extracellular biopolymer they produce. The bacteria are attracted to the metal surface because organic molecules adsorbed there provide nutrients. When a number of bacteria have attached to a surface, they begin producing an extracellular biopolymer, which is known as biofilm. This biofilm has a slippery consistency; hence its common name is "slime."

Problems Associated with Biofilms

1. **Fouling:** A problem that biofilms cause in cooling systems that most water treaters and maintenance personnel are very familiar with is fouling. Algal biofilms foul cooling tower distribution decks and film fill where these surfaces are directly contacted by sunlight. Biofilm accumulations in these areas cause flow restrictions and result in decreased tower efficiency. Portions of the mass can also break loose and be transported to other parts of the system, causing blockages and providing nutrients for various strains of bacteria.

2. **Resistance to Heat Transfer:** Bacterial biofilms develop most frequently on heat transfer surfaces as temperatures there favor the rapid growth of many strains of bacteria. Biofilm fouling of heat exchangers is a major operational problem because of biofilm's extreme resistance to thermal conductance. Table 1 shows the thermal conductivity values for several deposit-forming compounds compared to biofilm. A lower number indicates a greater resistance to heat transfer. (The thermal conductivity of Iron is provided for comparison).

Substance	Thermal Conductivity $W.m^{-1}.K^{-1}$
$CaCO_3$	2.6
$CaSO_4$	2.3
$Ca_3(PO_4)_2$	2.6
Fe_2O_3	2.9
Analcite	1.3
Biofilm	0.6
Iron (for comparison)	80

Table 1: Thermal conductivity comparison of deposit-forming compounds and biofilm

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3. **Scale:** In addition to general fouling, biofilms can contribute to scale formation as well. Carboxylate functional groups in the biopolymer attract calcium ions from the recirculating water and fix them in place in the biofilm matrix. There they are available to react with carbonate ions which are also present. Once this nucleation of the calcium carbonate molecule has occurred, a crystal can grow. Biofilms can also trap calcium carbonate particles that have already precipitated. These particles can then serve as crystal growth sites.
4. **Corrosion:** Biofilms cause or contribute to a large percentage of the corrosion that occurs in cooling water systems. Iron oxidizing bacteria can cause severe localized corrosion, and the biofilms they and other bacteria strains produce can serve as sites for the proliferation of anaerobic bacteria such as sulfate reducers. These types of bacteria produce byproducts that are acidic and cause high localized corrosion rates.