ELIMINATE BIOFILM TO INCREASE ENERGY EFFICIENCY IN WATER SYSTEMS

How does the elimination of Legionella bacteria relate to biofilm? For Legionella bacteria to reproduce in water systems, the bacteria must enter a biofilm. Consequently, the absence of biofilm means that the Legionella bacteria cannot reproduce.

Risks of reclaimed makeup water. Evaporative cooling water systems that use reclaimed (recycled) water always have a high risk of bacteria growth due to the low concentrations of contaminants that serve as nutrients. The use of reclaimed water in evaporative cooling systems is very common in data centers and manufacturing plants in arid locations.

Biofilm is ubiquitous. Some of these bacteria species excrete a slimy material – biofilm – onto the heat transfer surfaces. Biofilm is invisible and it's impossible to inspect the heat transfer surfaces during the plant's operation. This biofilm dramatically reduces the heat transfer efficiency of the chiller: biofilm is four times as insulating as the same thickness of hardness scale! The presence of biofilm increases water, treatment chemicals, and energy consumption. Some studies indicate that removing biofilm could decrease energy costs by 30%.

Biofilm grows rapidly in idled chillers. There's another hidden risk: biofilm growth accelerates in stagnant water, especially in stand-by chillers. When these chillers return to service, the turbulent water flow removes the top layer of the biofilm, distributing these bacteria that want to attach to surfaces through the rest of the chillers. Unfortunately, a thin layer of biofilm remains.

Conventional treatment for biofilm is not effective. In reality, conventional biocide chemicals do not eliminate biofilm because the cooling water system is very complex and these highly toxic, very expensive chemicals require intermittent feed for two important reasons: First, they are very expensive compared to bleach or bromine and they need a high concentration to kill bacteria. Second, if these biocides are fed continuously, the biocides in the blowdown would kill the bacteria in the municipal water treatment plant that needs thriving bacteria to break down toxic compounds. If the blowdown is sent to the local watershed, it would kill the aquatic organisms in the stream, river, lake, or ocean.

Consequently, the intermittent feed of biocide chemicals allows the biofilm to proliferate because the water treatment supplier must estimate the frequency of chemical feed and the duration based on the environmental conditions (for example, ambient temperature, seasonal airborne contaminants, process leaks). The consistent inability to provide precise feed rates of biocides results in poor control of bacteria and biofilm.

Lack of real-time biofilm measurements. Most importantly, there's no proof that an intermittent feed treatment protocol can be effective – because very few sites have online biofilm measurements.

7267 Chesapeake Dr., Exmore, VA 23350-4414 • Office: 757-442-5308 • Cell: 609-865-8151 • Fax: (509) 351-5503
E-mail: huchler@martechsystems.com • Web Site: www.martechsystems.com

Availability of online biofilm sensors. There are three online biofilm sensors available; one sensor uses ultrasonic technology, and two sensors use electrochemical technology.

> **Ultrasonic technology.** Solenis, a water treatment supplier of chemicals and services based in the U.S., has developed an ultrasonic biofilm detection system, ONGUARD™ 3B Analyzer that can distinguish between hard deposits and biofilm (~10 micron detection accuracy). This sensor requires a reaction chamber to precisely control the sample flow rate to measure the thickness of the biofilm and calculate the heat transfer loss. The ultrasonic sensor is a component of Solenis' ClearPoint℠ biofilm detection and control system leased to Solenis' customers.
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> The ideal buyer for the ONGUARD™ 3B analyzer is for complex process cooling applications that want to optimize their chemical treatment program and track their lost opportunity caused by the loss of heat transfer from biofilm. For a broad range of industries and processes, the ONGUARD™ 3B analyzer is much too sophisticated, expensive, and constrained due to the requirement to become a Solenis customer for water treatment chemicals and services.
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> **Electrochemical technology.** There are two suppliers of electrochemical online sensors that sell directly to the public: Structural Integrity Associates' (SIA) BIoGeorge™ and ALVIM Biofilm Monitoring System. These electrochemical sensors do not require a reaction chamber because they do not measure biofilm thickness or provide calculations of heat transfer loss. For most applications, the measurement of the biofilm thickness is not relevant because the objective is to identify the first evidence of biofilm and initiate biocide treatment. These sensors can be installed in specific locations such as stagnant sumps that have a high risk of biofilm.
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> The supplier of the BIoGeorge sensor provides a broad range of services; however, the biofilm sensor is their only product. Consequently, there is very little marketing information, application guidelines, case histories, or peer-reviewed technical papers. The focus of the supplier of the ALVIM Biofilm Monitoring System is exclusively biofilm monitoring products and services. In contrast with the BIoGeorge supplier, ALVIM has a substantial amount of marketing information, application guidelines, case histories, white papers, research projects, and peer-reviewed technical papers.

Applications for biofilm sensors. Loraine is working with two of her clients to use the ALVIM online biofilm sensor. One client, a manufacturer of semiconductor chips, needs to monitor biofilm in reclaimed water supplied to an evaporative cooling water system for comfort cooling. The other client, a beef processing plant, needs to monitor biofilm in the water in the humidifier system. This client wants to eliminate the presence of Legionella in the water droplets in the conditioned air in the production areas.

Sustainable, effective solution to remove biofilm. The field study of the Plasma Disinfection System (PDS)[1] in an evaporative cooling water system at the headquarters of a medical device company in northern New Jersey proved the effectiveness of the PDS in eliminating Legionella bacteria in the cooling water.

[1] Patrick Hughes, President, Reverse Ionizer, phughes@reverseionizer.com, www.reverseionizer.com

The PDS technology is a sustainable solution that eliminates toxic non-oxidizing biocides, improves energy efficiency, and is a cost-effective solution that will eliminate biofilm. The PDS has three technologies:

a. **Non-thermal plasma** is a novel technology that uses plasma – the fourth state of matter - in the reaction chamber. These filaments kill or disable bacteria by contact with the plasma and low concentrations of oxidizing biocides. The energy quickly dissipates before exiting the reaction chamber.

b. **Copper-silver ionization** is a proven technology to kill organisms in the biofilm: the silver ions lyse the cell wall, and the copper ions poison the organism. The use of copper-silver ionization as the only biocide in evaporative cooling water systems is ineffective; however, this technology is very successful when paired with other types of biocides.

c. **Oxidizing biocide** uses electrolysis of a salt solution to create bleach and dissolution of bromine pellets to create an oxidizing biocide that is effective in alkaline cooling water.

The non-thermal plasma system is fully instrumented for fail-safe operation and includes a human-machine interface, data acquisition, and remote operation.

This technology results in a significant reduction in chemical costs, water, and other OpEx costs, and extends the useful life of the cooling system equipment. The most compelling opportunity is the reduction in electrical costs due to the elimination of biofilm.

Ms Huchler designed and conducted a six-month field study of a novel non-thermal technology that killed Legionella in an evaporative cooling water system at a corporate headquarters. Ms Huchler has published two technical papers documenting the performance of this novel technology that used both a manual and an online, qPCR, field, Legionella test devices.

- *TP22-24: Managing Legionella Using an Innovative Bacterial Control System and Rapid Genetic Legionella Testing (2/2022)*
- *IWC 22-67: An Innovative, On-line, Automated Field qPCR Legionella Test Device (11/2022)*