Case Study Summary:

Using ATP to Reduce Risks from Legionella in Cooling Towers

Problem: In France, Legionella concentrations in cooling water must be kept below regulatory levels. If these levels are exceeded, a cooling tower must be shut down until low concentrations can be achieved. For manufacturing facilities that rely on cooling systems, this may require the production process to be shut down.

Facility: A semi-conductor manufacturing facility in France, which operates a large cooling water system with 19 cooling towers.

Investment: LuminUltra's QuenchGone Aqueous (QGA) test kit for measuring adenosine triphosphate (ATP).

Economic Analysis: LuminUltra's 2nd Generation ATP testing demonstrated that a new biocide strategy using a chlorine dioxide and hypochlorous acid blend was effective for controlling microbiological growth in the cooling water systems. The cost for the new biocide equipment and QGA test kits for the biocide evaluation were approximately €100,000 and €6,000, respectively. After making the switch, the facility implemented routine ATP monitoring and was able to eliminate the routine use of hypobromous acid as well as a biodetergent and isothiazolinone, reducing total operating costs by €170,000 per year. The cost for the biocide evaluation and new equipment was recovered within the first year of operation of the new system.

LuminUltra's 2nd Generation ATP testing also identified critical locations that were particularly susceptible to increased growth and provided an effective solution for ongoing monitoring. This allowed operators to quickly identify and resolve risks before they could become major issues that require cooling towers and production processes to be shut down.

Synopsis: A manufacturer of semi-conductors used LuminUltra's 2nd Generation ATP testing to improve their cooling water biocide and microbial monitoring program. The full case study follows.

Case Study:

Using ATP to Reduce Risks from Legionella in Cooling Towers

A semiconductor manufacturing facility in France relies on an extensive cooling system to maintain stable conditions throughout their production facilities. The cooling system includes 19 cooling towers and 14 cooling water networks spread over a 135-acre site.

In order to prevent outbreaks of Legionnaire's disease, France's regulations require cooling tower operators to maintain *Legionella pneumophila* concentrations below 1,000 CFU/L. If concentrations are between 1,000 and 100,000 CFU/L, the facility must implement corrective actions and review their risk analysis. If concentrations exceed 100,000 CFU/L, then a cooling system must be shut down until levels return below 1,000 CFU/L. For this manufacturer, an exceedance would result in a costly shut down of the production process, which could last for several days.

To reduce risks associated with Legionella, the facility provided centralized water treatment and disinfection using hypobromous acid (HOBr). HOBr is an effective oxidizing biocide that operates much like hypochlorous acid (HOCl). While HOBr is slightly weaker than HOCl, it is more effective under higher pH conditions. However, it is also toxic to non-target organisms, so discharge regulations are often relatively strict. Furthermore, bromine products are typically relatively expensive compared to chemicals such as sodium hypochlorite or chlorine gas.

While using HOBr, the facility frequently exceeded regulatory levels for Legionella. Therefore, operations staff were interested in evaluating alternative biocide treatment options and new microbial monitoring strategies. A biocide assessment was completed using LuminUltra's QuenchGone Aqueous (QGA) test kit, which measures adenosine triphosphate (ATP). The new monitoring program with ATP was critical for identifying areas in the system that were particularly susceptible to microbial growth and for providing an early warning for operators so that corrective actions could be implemented rapidly, before Legionella levels approach the regulatory threshold. The results from this evaluation are presented in the case study below.

Results

LuminUltra's 2nd Generation ATP testing was used to evaluate the efficacy of several biocide treatment approaches. ATP is a molecule that is present in all living cells, so its concentration in a sample can provide a direct indication of its total microbial content. In this particular case, testing was completed using the QGA test kit, which specifically measures cellular ATP (cATP), which is contained only within living cells.

Different biocides were applied under full-scale conditions over the course of approximately one year. During this period, ATP levels were routinely monitored throughout all cooling networks at the facility. All ATP measurements were performed within two hours of sampling. Controls were also included to verify that measurements were not affected by residual biocide or other sample components.

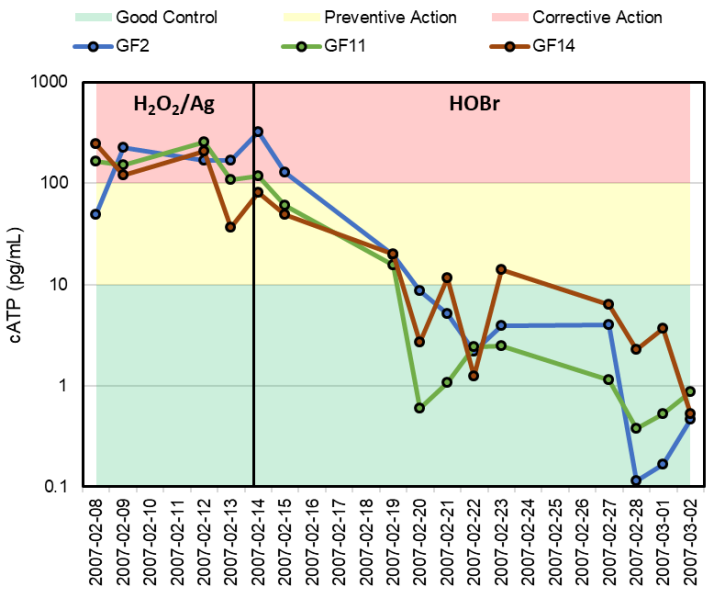

Figure 1 – Initial Biocide Evaluation

During the trial period, three biocides were evaluated for the make-up water: oxygenated water stabilized with silver ions (H_2O_2/Ag), HOBr, and a hypochlorous acid and chlorine dioxide blend (HOCl+ClO_2) that was generated on-site. Other than the biocide treatment, consistent water quality was maintained throughout the study period.

Results of the initial evaluation comparing H_2O_2/Ag with HOBr are shown in Figure 1. Samples were collected from 10 networks, but results are shown for three locations for clarity. In general, results were consistent for all networks that were tested. The figure also includes green, yellow, and red backgrounds for concentration ranges that indicate 'Good Control', 'Preventive Action Required', and 'Corrective Action Required'. Testing demonstrated that HOBr was more effective at maintaining low cATP concentrations compared to the H_2O_2/Ag treatment. With the H_2O_2/Ag treatment, high cATP concentrations were observed even when H_2O_2/Ag residuals reached as high as 200 mg/L.

Following the tests with H_2O_2/Ag, the cooling networks were flushed and the biocide was switched to HOBr, with residuals maintained between 0.5 mg/L to 10 mg/L. This improved cATP concentrations throughout the system.

A second round of testing was then completed to determine the impact of localized biocide addition in specific networks. Several conditions were monitored, including the use of H_2O_2/Ag, HOBr, and two dosing levels of HOCl+ClO_2. The combined HOCl+ClO_2 dosing was controlled based on the water's oxidation-reduction potential (ORP) with the low and high dose producing an ORP of 500 mV and 600 mV, respectively. LuminUltra's 2nd Generation ATP testing demonstrated that the on-site generated HOCl+ClO_2 was more effective at controlling microbiological growth compared to the H_2O_2/Ag product. It also demonstrated that HOCl+ClO_2 and HOBr treatments were comparable when the HOCl+ClO_2 was dosed at 600 mV (or higher at some locations).

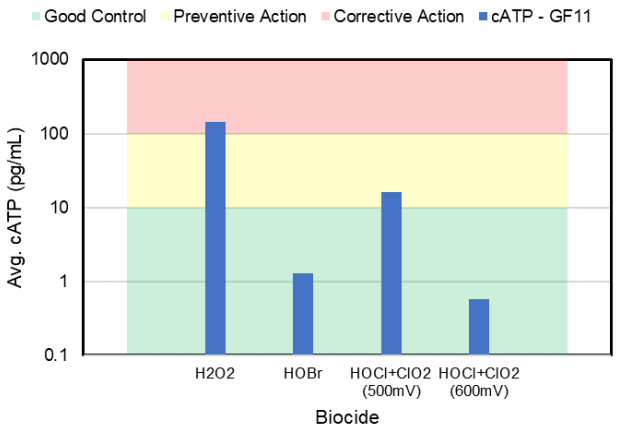

Figure 2 – Local Biocide Addition for Network GF-11

The evaluation also included quantitative polymerase chain reaction (qPCR) testing to measure Legionella in the cooling water networks. Results from network GF12 are shown in Figure 3. The data demonstrates that the two measurements were related, as high concentrations of cATP were

associated with higher levels of Legionella measured by qPCR. This relationship was consistent for each of the three biocides that were used.

Using LuminUltra's 2nd Generation ATP, the study demonstrated that HOCl+ClO_2 could effectively control microbiological growth in the cooling water system, thereby reducing the risk from Legionella. Moreover, 2nd Generation ATP testing was used to optimize biocide dosing, allowing the facility to reduce microbiological risks while minimizing chemical costs. 2nd Generation ATP and qPCR testing were subsequently added to the facility's ongoing monitoring program to control growth in the cooling water system, allowing operators to quickly implement preventive actions whenever there were indications of increased growth. Initially, the monitoring program included daily ATP testing and weekly qPCR testing of each network. Once conditions stabilized, ATP testing was reduced to two to three times per week depending on the network and qPCR testing was reduced to once per month prior to regulatory monitoring.

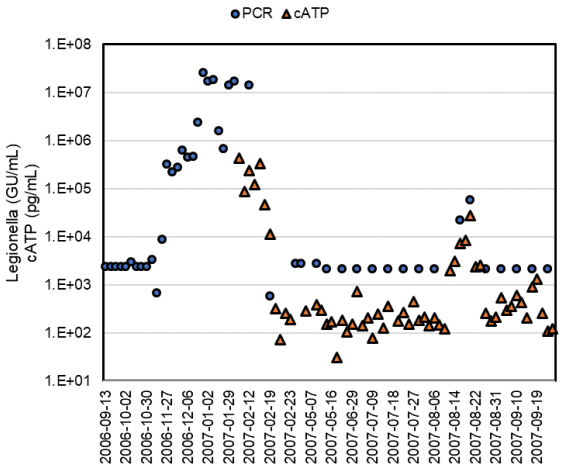

Figure 3 – Comparing Legionella and cATP Measurements

Economic Analysis

Following the results of this study, the facility completed a system-wide switch to HOCl+ClO_2 biocide treatment. LuminUltra's 2nd Generation ATP testing demonstrated that this new option was effective at preventing microbiological growth and identified optimum doses for different networks. The cost for the new HOCl+ClO_2 systems and QGA test kits for the biocide evaluation were approximately €100,000 and €6,000, respectively. After making the switch and implementing routine ATP testing, the facility was able to eliminate the use of HOBr as well as a biodetergent and isothiazolinone, reducing operating costs by €170,000 per year*. Therefore, the costs of the biocide evaluation and new equipment were recovered within the first year of operation.

Most importantly, operators were able to use LuminUltra's 2nd Generation ATP testing to identify critical locations within the system that were most susceptible to microbial growth. Through routine monitoring of these locations, operators are able to rapidly detect microbiological growth and implement preventive actions, thereby preventing conditions that could require the cooling towers and production process to be shut down.

**Includes operating cost reduction of €190,000 per year for switch to new process and cost of €20,000 per year for routine ATP testing in each network three times per week.*