Clean-In-Place Optimization in the Food & Beverage Industry

Introduction

Clean-In-Place (CIP) processes are essential to the food and beverage industry, as well as any other batch processes where residual contamination can negatively impact product quality. The following factors hold critical importance in CIP management:

- **Time** – Time spent conducting CIP cycles is time that is not spent on production, so CIP cycles should be as short as possible while still being effective.
- **Chemicals** – Under-dosing of cleaning chemicals increases the risk of contamination and biofilm formation and will also necessitate additional chemical treatments to mitigate these more serious issues later. Conversely, over-dosing of chemicals also carries a significant cost and can upset downstream wastewater treatment processes.
- **Water** – Depending on the size of vessels and lines that require cleaning, water requirements can be excessive. These costs can be compounded by the amount of energy and chemical needed when water usage increases.
- **Energy** – The costs associated with pumping as well as heating of water and cleaning agents is directly tied to the amount of water and chemical required. Considering that electricity costs are often among the largest expenses in operating industrial processes, these costs can escalate quickly if water and chemical usage is not optimized.

Figure 1: A typical Clean-In-Place System

The Challenge: How can the effectiveness of a CIP cycle be quickly verified?

A holistic water quality monitoring toolbox including rapid microbiological monitoring enables all aspects of CIP cycles as well as the production process as a whole to be optimized.

ATP testing originated decades ago with the use of 1st Generation swab-based devices. These systems effectively measure microbial content on surfaces in food and beverage applications. They provide a qualitative "pass/fail" confirmation of surface cleanliness. However, swab testing carries some drawbacks:

1. **Sampling Accuracy** – Swabs only detect ATP on the surface with which they come in contact. They can't measure an entire system, as some surfaces are inaccessible, and the bioburden often differs from one surface to another.
2. **Unsuitable for Fluids** – Swab testing can't be used to measure aqueous samples. If swabs are dipped in a fluid, it renders the measurement inaccurate due to significant sensitivity limitations.
3. **Qualitative Results** – Swabs provide a qualitative "pass/fail" measurement or Relative Light Units (RLU) rather than a quantitative estimate of microbial counts that can be compared to other traditional microbial tests.

Example 1: Food processing QA/QC

Figure 1 illustrates how the water cycle within a food processing facility can be quickly characterized in terms of risk. In addition to screening municipal inlet water, the cleanliness of purified feed water can be verified in minutes so that contamination incidents can be detected at the earliest point. Considering that make-up water is often the fastest and most common route of contamination, rapid surveillance of this critical control point is of utmost importance.

Water quality can also be closely monitored to ensure clean water for CIP cycles and that adequate performance is achieved. High ATP levels in final rinse water can be indicative of incomplete cleaning, meaning that process should continue until a sufficiently low ATP result is returned. Similarly, being able to immediately verify clean rinse water enables immediate termination of the CIP process, thereby avoiding excessively long cleaning cycles and water wastage.

Example 2: Beer Brewing CIP

As is the case in food processing, CIP systems are used extensively in breweries to sufficiently clean fermenters after beer brewing runs. Contaminated beer impacts the quality of the beer (i.e. flavour, aromas, or haziness), and in the worst case, can result in batch spoilage.

Following each batch, effective cleaning of the fermenter is essential prior to the next batch. If cleaning is not adequate, the following fermentation run could be inhibited due to the presence of bacteria. While bacteria can be detected using selective bacterial counts or microscopic analyses, it is too late to apply corrective action once results are known. Rapid microbiological analyses using a rapid method such as 2nd Generation ATP monitoring provide a potential solution to this challenge.

Figure 3 shows the results of a CIP process around a fermentation run. The feedwater ATP tests prior to entering the chiller system indicate water with very low bioburden levels, but the outlet of the chiller showed far greater values. This is indicative of biofilm/residue accumulation in the chiller, so the goal of the CIP cycle should be to reduce this to lower levels. However, after a rinsing cycle, the ATP concentration at the chiller outlet was significantly higher than when the process began. This clearly indicates that the cycle must continue to adequately purge the accumulated material from the system and reduce the risk of contamination to a safe level.

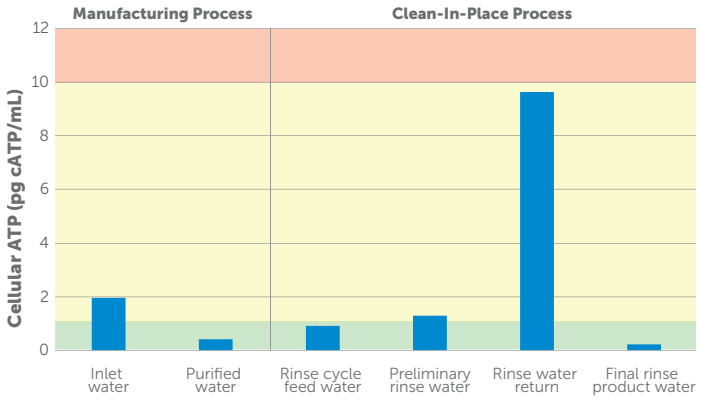

Figure 2: ATP screening tests in production and CIP processes

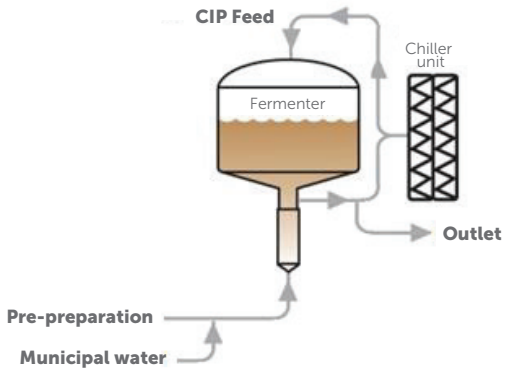

Figure 3: Fermenter Schematic

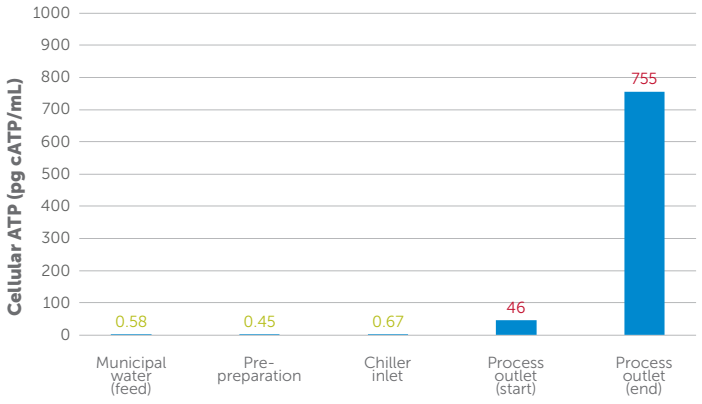

Figure 4: Fermenter rinsing cycle results

Summary

2nd and 3rd Generation ATP monitoring represents a major leap forward in rapid microbiological field testing. In general, the addition of this technology facilitates the following opportunities for CIP optimization:

- Reveal contaminated product at the earliest possible point.
- Optimize inspections and cleaning cycles to close pathways of contamination and minimize downtime between batches, thereby maximizing profitability.
- Streamline equipment maintenance and servicing (e.g. filters, purification systems).

The integration of 2nd generation ATP monitoring to QA/QC programs in the food & beverage industry can have a direct impact on profitability. The latest-generation solutions involve continuous monitoring of microbial load. ATP online analyzers provide much greater insight into process conditions than has ever been possible before; helping to optimize process control and mitigate the risks presented by microbial load. Contact your local Hach® Sales Manager for assistance by visiting www.hach.com.

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