Use of a Bio-fluorescent Particle Counting System to Support a Reduction in Water Loop Sanitization Frequency

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Introduction

A green initiatives case study is presented on the implementation and use of a bio-fluorescent particle counting (BFPC) technology to support and assess a reduction in water loop sanitization frequency. BFPC technology is based on bio-fluorescence, requires no sample preparation, and systems continuously monitor and report total and bio-fluorescent particle counts in real time. This continuous bioburden data and feedback can be used to improve process understanding, more quickly assess the impact of process changes, and improve process control. Data is presented from a BFPC system installation on a personal care products water loop. Information on system implementation, data processing methods used, and progress made on a reduction in water loop sanitization is presented.

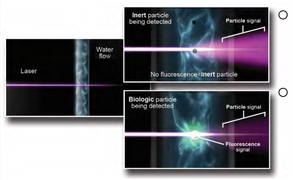
Background

Bio-fluorescent Particle (BFP)

A Paruroctonus scorpion fluorescing under a blacklight *Courtesy wikipedia.org*

- Some particles naturally fluoresce - they absorb energy from light of a shorter wavelength and release this energy as light at a longer wavelength.
- Scorpions under a UV light are an example.
- All cells contain many fluorescent molecules.
- NAD(P)H and Riboflavin are examples that fluoresce when under 405nm light.

Bio-fluorescent Particle Counter (BFPC)



- Enhanced particle counters, capable of continuous and real-time detection of inert particles and microorganisms (i.e. BFP) in air or water.
- BFPCs use detection of:
  - Scattered light for particle enumeration
  - Intrinsic or natural fluorescence for classification of particles as BFP or inert

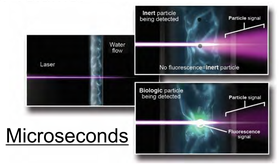
IMD-W BFPC System

- IMD-W system is a Rapid Microbiological Method (RMM), and more specifically a Bio-fluorescent Particle Counter (BFPC).
- Enables continuous, online water sampling and bioburden monitoring.
- Uses a 405nm laser to monitor for bioburden - not growth dependent, requires no staining or reagents.
- Data output up to every second, counts reported per user selected time or volume.

BFPC - Different Bioburden Signal

CFU ≠ AFU

Days vs. Microseconds

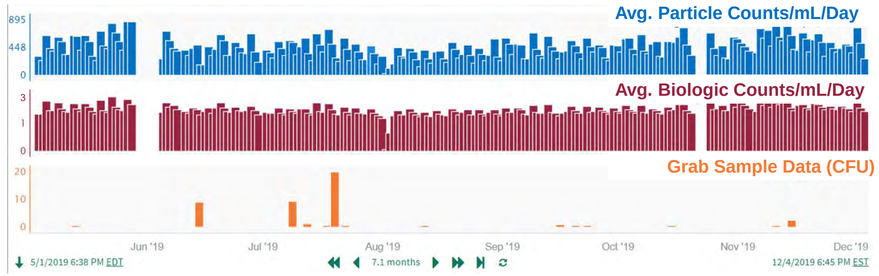


Colony-forming unit (CFU) - unit used to estimate number of viable and culturable bacteria or fungal cells in a sample.
Auto-fluorescence Unit (AFU) - unit that reflects both size and fluorescence of particle and can include viable but non-culturable cells. Often a more sensitive estimate of bacteria and fungal cells in a sample.

Water System Application

BFPC Installation on Personal Care Products Water System

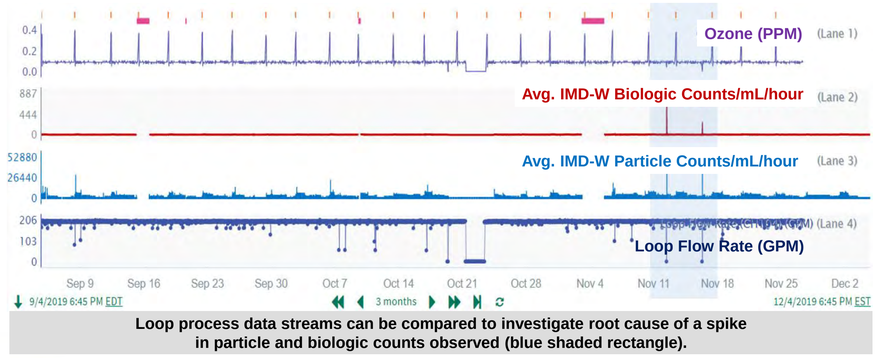
- IMD-W system is installed on the loop return of a personal care products high-purity water system.
- Loop is only a few years old and constructed of stainless steel.
- The IMD-W system was installed in May of 2019, with stable biologic and particle counts per mL since – detecting an average of only 2.9 biologic counts per mL.
  - IMD-W operates continuously, analyzing 7,200mL of water per day (24 x 7).
- Water grab sample results are also shown. None of these results were considered out of specification, and were obtained episodically as opposed to continuously.



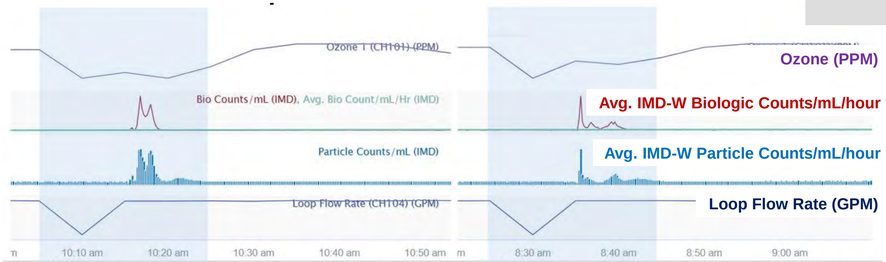
Average IMD-W total particulate and biologic counts per mL per day, reported continuously, and episodic grab sample results from high-purity personal care products water system.

Improved Process Insight

- Loop process data streams have been pulled into a data analytics tool called Seeq®.
  - Seeq permits a continuous comparison of IMD-W and other process data to gain process insight.
  - Within Seeq, times can be identified when alert and action level alarms are not applied (e.g. during periods of sanitization where particle counts are higher).
- Ozone sanitization, average IMD-W biologic counts/mL/hr and particle counts/mL/hr, and loop flow rate data are shown in the plot to the right.
- An ozone sanitization is performed twice weekly at a concentration of ~0.4 PPM.
- In looking at biologic and particle counts per mL per hour instead of per day, two outliers were identified between May and December, as shown in the blue rectangle.



Loop process data streams can be compared to investigate root cause of a spike in particle and biologic counts observed (blue shaded rectangle).

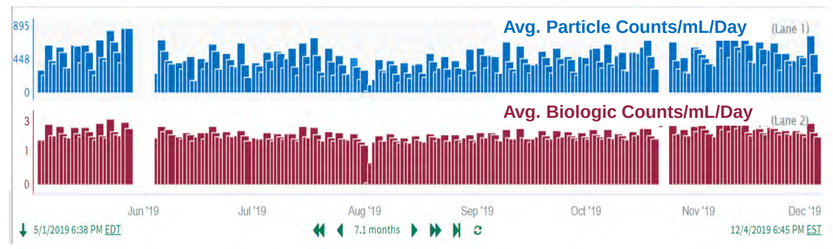


A quick stop and restart of loop flow is believed to have dislodged particles causing the observed spikes in particle and biologic counts, which recovered to a baseline in less than five minutes.

- Although these spikes were not significant enough to impact average counts per mL per day, zooming in to results per hour highlighted a change in loop data.
- A decrease in loop flow rate (bottom, dark blue line in plot above and zoomed in plot on the left) was found to coincide with these spikes in IMD-W particle and biologic counts.
- Quick stop and restart of the loop flow is believed to have significantly dislodged settled particles in the two cases.
- Particle and biologic counts were found to return to baseline levels in less than five minutes, as shown in the plot to the left.

Conclusions and Next Steps

- Outside of the two outlier spikes identified in November, loop particle and biologic counts have been stable.
- IMD-W continuous data highlighted a change in loop performance that impacted particle and biologic counts.
  - Plan to investigate root cause of the water loop flow rate drops.
- Based on overall stability in IMD-W counts and culture results, plan to investigate reducing ozone sanitization frequency, cycle time or concentration to support energy reduction.
  - IMD-W and grab samples results will be used to monitor counts for at least 30 days thereafter to confirm no significant change in baseline count levels.



Based on significant IMD-W continuous data since May of 2019 showing general stability in counts and ability to continuously monitor counts after a change, plan to investigate reduction in ozone sanitization frequency, cycle time or concentration to support energy reduction.