Introduction

BioSense is a sensor that can measure biofilm activity and is designed to act as an early warning system for biofilm control, allowing operators to deal with biofilm before it becomes a problem.

BioSense is a unique solution, and people often have questions about how BioSense presents its data, and what constitutes a 'true' biofilm response. This technical note aims to provide clear and concise answers to these questions.

What is biofilm?

Biofilm is a collection of micro-organisms and their secreted substances, commonly known as "slime", that has adhered to a surface. The formation of Biofilm is the natural response of micro-organisms to environmental pressures, such as biocides. Biofilm is considered a 'high risk contamination' by the UK Health and Safety Executive\(^1\) and is generally considered to be both dangerous and costly to businesses. Biofilms proliferate legionella\(^2\) and severely hamper heat transfer\(^3\). Biofilms are also very resistant to biocides\(^4\). The presence of biofilm can increase micro-organism resistance to antimicrobial agents by 10-1000 times\(^5,6\). Even 'specialist' disinfectants such as chlorine dioxide, known to be effective against biofilm, can require doses 10 times higher than biofilm free waters\(^7\).

What can BioSense tell me?

The BioSense measures the electricity generated by biofilm growing on its surface. It also provides a preferential site for biofilm growth. In effect the BioSense provides a landing site for adherent cells, and an electrically stimulating environment to give any biofilm the best chance of survival. If a biofilm can grow in a water system then it will grow on the BioSense first. BioSense tells you when the conditions in your water system are changing in a way that can support Biofilm growth. This may be from a system with no biofilm growth to some biofilm growth (eg. a hospital water system) or may be a system going from some biofilm growth to more biofilm growth (e.g. a cooling tower).

What is the BioSense "Activity"?

The BioSense interprets the raw data from the sensor in several ways, looking for patterns and rates of change, and outputs "Activity". This scale goes from 0.0-10.0. Any value above 0.0 represents some biological activity on the surface of the BioSense probe. The higher the value the greater the biological activity detected. Whether or not that biofilm is present throughout the rest of the water system will depend on many factors,
however the more biofilm activity on the sensor the higher the risk of there being activity elsewhere in the system.

Any deviation from 0.0 activity is likely to be because of biofilm activity, however, due to the sensors’ sensitivity, it may be activity in a biofilm that is too small to be visible (see Graph One). This kind of transparent biofilm can often be detected by running a gloved finger over the probe, and feeling the ‘slime’. Whether this response would initiate an action is completely up to the operator, and different applications take action at different activity levels.

**At what activity level should I take action?**

BioSense owners need to decide at what activity level they decide to take action, and that depends on the application. Hospitals tend to take action at any reading over the base 0.0, whereas cooling towers can be more tolerant of biofilm and are more likely to look at changes in biofilm activity. If you discuss your application with a PI specialist, they will be able to help you, but will not be able to recommend a threshold.

**Does activity relate to the thickness of the Biofilm?**

No. Activity is calculated based on the biofilm’s activity not the thickness. What activity allows us to do is provide an early warning system, Graph One shows how a BioSense can detect activity, even before biofilm is visible. Disinfecting or cleaning biofilm before it becomes established can help save time, money, and chemicals, whilst also providing a valuable safeguard against diseases such as Legionnaires.

**Does the BioSense tell me what sort of micro-organisms I have in the water?**

BioSense measures biofilm activity and does not differentiate between different micro-organisms. What most people want to know is whether Legionella is in their water. Legionella is a parasitic bacterium, and needs other micro-organisms present in the water in order to multiply. Biofilm is the ideal host for Legionella, and so controlling biofilm is also controlling a Legionella precursor.

**Can I test the BioSense in the lab?**

When people test BioSense in a lab they generally do not have a lot of success. This is due to the experiment and is not due to the sensor itself. A biofilm tends to form in ‘lean’ conditions, when forming a biofilm gives the micro-organisms a survival advantage. Biofilm grown in a lab tends to not to be the same as in the field, in that laboratory biofilms are monocultural, induced and generally they are fed. In these conditions, the BioSense doesn’t give the biofilm an advantageous surface to grow on and so the results are often poor, as opposed to the results from field tests. If a lab test must be performed, it is recommended you speak to one the team at Process Instruments, who can help you with the testing procedure and data interpretation, or click [here](#) to read our technical note.
Does risk correlate to planktonic counts or dip slides?

No. Because of the nature of biofilm, and its resistance to biocides, it is possible for a water system to have clean bulk water, with residual disinfectant, and still have biofilm present on any surfaces. Any deadlegs or areas of the system that are poorly circulated will also contribute to this discrepancy. Planktonic counts only give information on free floating micro-organisms and not the sessile, non-moving micro-organisms present in biofilm. The commonly used field test for planktonic counts, a ‘dip slide’ also suffers from a growth bias. The dipside is a thin layer of nutrients that many micro-organisms (but not all) can grow on, which is incubated for a few days and then counted. The problem with this method is that not all micro-organisms can grow on these nutrients, notably Legionella¹, meaning potentially harmful pathogens go uncounted.

Graph Descriptions

Graph One

Graph to show BioSense response to biofilm growth with associated pictures of the probe surface.

This graph shows how BioSense can be used. The BioSense responds to biofilm even before the biofilm is visible. At this stage the biofilm is much easier to get rid of than at later stages of biofilm development.

Graph Two

Graph to show BioSense response to biofilm growth with active and passive currents.

This graph shows some of the raw data that determines how the activity is calculated. When discussing your BioSense readings with us, it is very useful to datalog the active and passive currents, as it gives us more information to work with. Datalogging on your CRIUS instrument is very simple to set up.

Graph Three

External BioSense test in 10,000L of water.

This graph shows an external biofilm trial on a large scale. The tail at the end of the graph corresponds with a physical clean of the sensor.

References

Graph to show BioSense response to biofilm growth with associated images of probe surface.

- BioSense Probe surface: Invisible biofilm "slime".
- BioSense Probe surface: Established biofilm.
- BioSense Probe surface: Biofilm dispersal.

Dates:
- 27/04/2015
- 29/04/2015
- 01/05/2015
- 03/05/2015
- 06/05/2015
- 07/05/2015
- 09/05/2015
- 11/05/2015
- 13/05/2015
- 15/05/2015

Activity scale from 0.0 to 10.0
Graph to show BioSense response to biofilm growth with active and passive currents

- Activity
- Act
- Pass

Initial Attachment

Biofilm Growth

Date (dd/mmm)
External BioSense Test in 1000L of nutrient dosed water

Notes:
- Blue spots show where small amounts of nutrients were added after the system had been running with no initial inoculation for 2 months.
- Clear increases in activity value correspond to the addition of nutrients.
- The presence of biofilm was confirmed using ATP analysis.
- On the 5th of February the probe was cleaned manually.