Bioassay Validation Accurately Determines UV Dose

The UV dose delivered by a reactor is the key parameter used to confirm proper UV system sizing for a specific application. As such, a true baseline of performance is required to ensure permit requirements are met at the design conditions. The accuracy of data obtained through bioassay validation eliminates any ambiguity in this baseline. By contrast, theoretical estimates of equipment performance (e.g. using UVDIS 3.1 software) are prone to overstating the delivered UV dose because real-world factors are not considered. As a result, the most accurate method of determining and quantifying the delivered dose of a UV reactor is with bioassay validation. Reactor validation, through a bioassay, rigorously tests an actual UV system under a wide range of water quality conditions to characterize the system performance and enable accurate sizing and performance guarantees.

WHAT IS A BIOASSAY?
Bioassay is a procedure used to determine the UV dose of a UV reactor by measuring the inactivation of a challenge organism at various flow rates and water qualities.

THEORETICAL SIZING IS INACCURATE

The UVDIS 3.1 sizing software enables engineers to estimate the theoretical UV dose. The UVDIS 3.1 software was developed almost 20 years ago, at a time when only low pressure, low output (LPLO) lamps were commercially available. In fact, the equations within the tool are based on modeling of LPLO lamp systems. The UVDIS 3.1 software makes no allowances for the high-output lamp technologies and advanced reactor geometries used today. As such, the software can and does significantly over-estimate the dose delivered by a UV system.

Figure 1 shows a project example where UVDIS over-predicted the delivered dose compared to the reactor's field data obtained through bioassay validation. As a result, the system will be undersized and disinfection performance will be compromised if UVDIS is used.

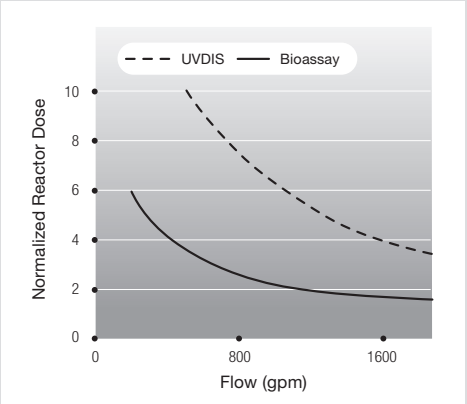

Figure 1. UVDIS and Bioassay Validated Dose. Doses were normalized (no units) to show relative magnitudes of performance. (Source: Petri, 2005)

BIOASSAY VALIDATION IS WIDELY ENDORSED

Bioassay validation is a process to collect data based on actual UV system performance under varying real-world conditions. As a result, it is widely endorsed by many leading engineers, manufacturers, regulators and design guidelines (e.g. NWRI/AwwaRF UV Disinfection Guidelines – May 2003 and USEPA UV Disinfection Guidance Manual – November 2006). For example, the majority of drinking water regulators do not accept theoretical dose calculations for drinking water treatment because of the inherent inaccuracies – only bioassay validated systems are accepted to ensure public health protection.

"…while UVDIS algorithm was an appropriate tool for sizing older style LP UV reactor systems in the past, the current industry accepted bioassay sizing methodology is far superior." (Petri, 2005)

BIOASSAY VALIDATION USES EMPIRICAL DATA

Unlike theoretical methods, such as UVDIS 3.1, field validation provides a true evaluation of actual UV dose delivered under a wide range of operating conditions, flow rates, and water quality criteria as summarized in **Table 1**. Field validation is the only way to accurately incorporate actual lamp output, lamp spacing, ballast efficiency, flow hydraulics, quartz sleeve transmission and other variables that affect disinfection performance. Theoretical dose calculations are inherently inaccurate because they cannot characterize a reactor's distribution of residence times and the UV output of its lamps. They rely on theoretical retention time and theoretical intensity – assumptions that do not address the diversity of UV system

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configurations now available as exemplified in **Table 2**. Furthermore, many assumptions are put into theoretical models and before a model can be deemed valid, it needs to be compared and proven with actual field testing results – which is rarely done and presents a very high risk when the model is used for reactor sizing. Bioassay validation is entirely different in that the methodology involves reactor testing under various water quality conditions and the empirical data collected is used for reactor sizing.

INSTALLATION EXAMPLE

In 2002, Longmont, Colorado, USA installed a competitor UV system that was unable to achieve their permitted disinfection limit. Several factors contributed to the disinfection system failure including an inadequately sized UV system. In 2007, the wastewater treatment plant installed a TrojanUV3000Plus™ (similar to **Figure 2**) sized based on bioassay validation and has since been able to meet their disinfection limit reliably. This highlights the importance of proper sizing based on bioassay validation in order to ensure disinfection performance (Youngberg, 2008).

References:

Petri, B., Scheible, O.K., Lawryshyn, Y., Robinson, J., Sasges, M.. *UVDIS Requires Validation for Sizing UV Reactors.* HydroQual Inc. & Trojan Technologies Inc.. WEFTEC, 2005.

Hartfelder, J.. *Ultraviolet Light Process Model Evaluation.* Brown and Caldwell, 2002.

Youngberg, C., Marko, K.. *UV Disinfection for a Real-World Effluent.* Water Environment Federation, March 2008.

Bioassay Validation (Delivered Dose)	UVDIS (Theoretical Dose)
• Real world testing of full-scale UV system conducted over a wide range of flow rates and water quality parameters • Determines delivered UV dose based on actual kill rate of microorganisms that flow through the reactor • Does not make assumptions regarding system parameters, such as lamp intensity, mixing, short circuiting and hydraulic performance • Validation protocols are thoroughly defined by both the USEPA and NWRI/AwwaRF	• Program is not endorsed by the USEPA, nor has it stayed current with advances in UV technology • A critical input to the calculation is lamp output (Watts), however, no industry-accepted standard method for absolute lamp output measurement exists • Program does not take into account critical operational parameters such as hydraulics, mixing, quartz sleeve transmission, etc. Values are assumed and not verified by UVDIS 3.1

Table 1. The above table is a brief summary of the differences between bioassay validation and theoretical UVDIS calculations.

Sizing Method	Competitor UV System (330W lamps)	TrojanUV3000Plus™ (250W lamps)
UVDIS	40	42
Bioassay	55	48
Manufacturer's Recommendation	34	48
SUMMARY	UV system is undersized since the bioassay testing demonstrated 55 lamps are actually required to meet the target dose.	UV system accurately sized based on empirical data and is backed by a lifetime disinfection performance guarantee.

Table 2. Theoretical calculations overstate dose (i.e. understate the number of lamps required) as seen in this independent study (Hartfelder, 2002).

CONSISTENTLY POSITIVE CUSTOMER FEEDBACK

"It works! I am amazed that we can kill so much just by shining a light through it."

"Maintenance is very easy and minimal. It is doing a great job, we are getting good results on our kill. I love the UV [system], I really do."

Average Overall Satisfaction Rating with Trojan = 8.8 out of 10

Source: 2009 Customer Satisfaction Survey

Figure 2. The TrojanUV3000Plus™ disinfection system is fully validated by an independent third-party and backed by a lifetime disinfection performance guarantee. Plants can be assured Trojan's UV system sizing is accurate and will perform as designed.

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