Natalie Hull, Ph.D.
Consulting Scientist
Hull Consulting, LLC
195 Tibet Rd.
Columbus, OH 43202, USA

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Jennifer Pagan, Ph.D.
Chief Technology Officer
AquiSense Technologies LLC
4400 Olympic Blvd.
Erlanger, KY 41018, USA

Re: Report Certification

To whom it may concern:

I hereby certify that the details contained within this report (Titled "PearlAqua Micro Validation Brief", and prepared by AquiSense Technologies LLC) are, to the best of my knowledge, true and accurate, and that all testing was completed under my supervision and in accordance with the procedures outlined in this report. I participated in this testing and report certification as a Consulting Scientist at Hull Consulting, LLC: The Ohio State University does not approve/disapprove these products or this work, and neither this report or certification represents the position of the University.

Natalie Hull

Natalie Hull, Ph.D.
Consulting Scientist at Hull Consulting, LLC and
Assistant Professor of Environmental Engineering at
The Ohio State University

PearlAqua Micro Validation Brief

June 2019

Background

Technology Type:	Ultraviolet Light Emitting Diode (UV-LED)
Application:	Water Disinfection
Product Type:	PearlAqua Micro™
Model Names:	PAQ-03B-350, PAQ-06B-350, PAQ-06C-350, PAQ-09C-350, PAQ-12C-350
Company:	AquiSense Technologies LLC
Address:	4400 Olympic Blvd, Erlanger, KY 41018, USA
Telephone:	+1 859 869 4700
Website:	www.aquisense.com

Product Description

PearlAqua Micro is the world's smallest mercury-free, UV-C LED product designed for water disinfection. Applications include medical devices, life sciences, remote communities, defense, emergency response, transportation, and commercial water. Five different models were validated for UV dose as shown in this report.

Table 1: *Model configurations tested in this report with test specifications*

Model Name	PAQ-03B-350	PAQ-06B-350	PAQ-06C-350	PAQ-09C-350	PAQ-12C-350
Operating Pressure	Discharge to atmosphere				
Power Draw of Tested Units	3.12 W	7.68 W	7.68 W	9.36 W	12.72 W
Test Water Temperature	22-27 Celsius				
Test Microbe	MS2 Bacteriophage ATCC15597-B1 T1UV Bacteriophage HER468				
UV Transmittance at 254 nm	98%				
Inlet/Outlet Connection	3/8" push fit				
Flow Rate Range (lpm)	0.1-2.2	0.27-3.16	0.44-6.0	0.48-5.6	0.45-10.0

Verification Testing Description

Testing consistent with US-EPA Ultraviolet Disinfection Guidance Manual (UVDGM)[1] methods was performed on each of the 5 models. Microbiological verification testing including collimated beam UV exposures and dose determination, sample dilution, sample plating, and plate counting was conducted at GAP EnviroMicrobial Services Ltd, facilities in London, ON, Canada. All microbial preparation and plating were completed by qualified staff in accordance with procedures outlined and ISO/IEC 17025 certification, with accreditation through the Canadian Association of Analytical Laboratories (CALA). The system operation and sampling were conducted at AquiSense Technologies facilities in Erlanger, KY, USA under the observation and assistance of Natalie Hull, Ph.D. from Hull Consulting, LLC (Assistant Professor at The Ohio State University in the Civil, Environmental, and Geodetic Engineering Department). Samples were shipped from the operation facility to GAP in accordance with the established procedures of the lab.

[1] Office of Water (4601) - EPA *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule*, Office of Water, EPA 815-R-06-007: 5-8 (2006).

Verification of Performance

The validation study was conducted on 5 different Pearl Aqua Micro reactor models at an influent Ultraviolet Transmittance (UVT) level of 98% at 254 nm and multiple flow rates. A summary of these results is provided in Table 2, where a maximum flow rate is assigned for each model as would be required to achieve a predicted Reduction Equivalent Dose of either 10, 16, or 40 mJ/cm^2 under comparable operating conditions.

Table 2: *Maximum flow rates to achieve a predicted LP UV Reduction Equivalent Dose of 10,16, and 40 mJ/cm^2 for each of the 5 tested models at 98% UVT$_{254\ nm}$.*

Model Number		PAQ-03B-350	PAQ-06B-350	PAQ-06C-350	PAQ-09C-350	PAQ-12C-350
Maximum Flow		lpm (gpm)				
Predicted LP UV RED (mJ/cm^2)	10[a]	1.2 (0.3)	2.0 (0.5)	4 (1.0)	5.5 (1.5)	8.0 (2.1)
	16[b]	0.9 (0.24)	1.5 (0.4)	2.5 (0.7)	4.0 (1.1)	5.0 (1.3)
	40[b]	0.25 (0.07)	0.50 (0.13)	1.0 (0.3)	1.75 (0.5)	2.25 (0.6)

[a] Estimated from T1UV data, [b] Estimated from MS2 data

Data from a conventional low pressure UV collimated beam experiment—commissioned as part of this study—were used to assign the flow-through Reduction Equivalent Dose (RED) delivered by each LED reactor for each microbe according to the method of the USEPA UVDGM. When these data are plotted as a function of flow rate, Figure 1, a clear trend is seen for all units and both microbes tested in this study. As per industry best practice, data points where the inactivation of a target species was below 1-log (i.e. <90% reduction) were not included in this analysis.

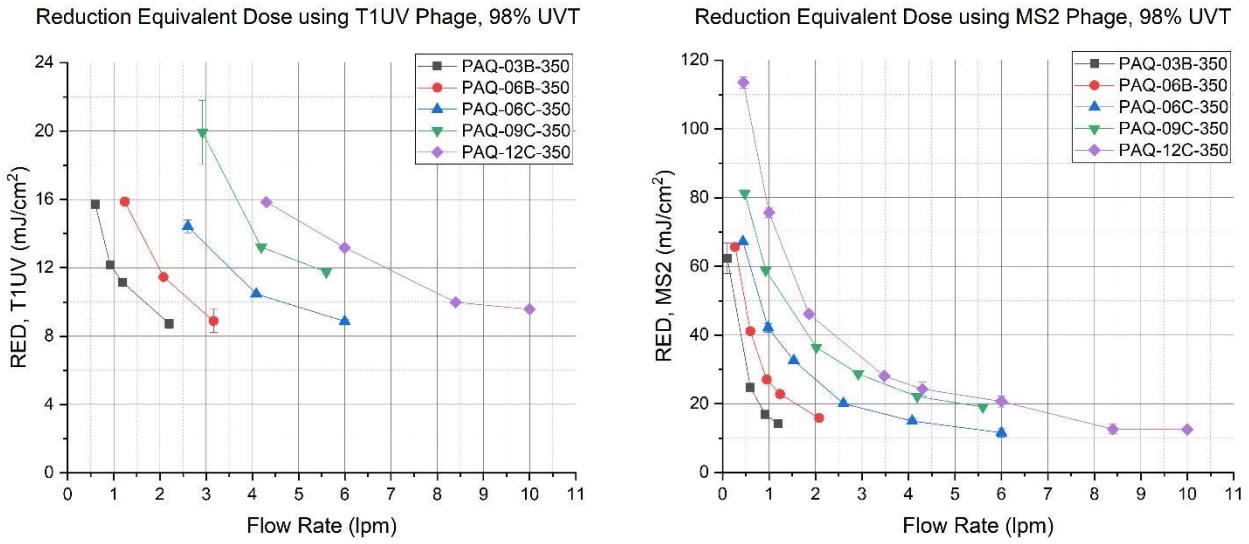

Figure 1: *LP UV Reduction Equivalent Dose versus flow performance of 5 Pearl Aqua Micro models tested with T1UV (left) and MS2 (right) at 98% UVT$_{254\ nm}$. Lines connect points showing the average RED for duplicate samples which were plated in duplicate, error bars show duplicate sample standard deviation.*

Some variation was observed when RED was calculated from the measured inactivation of each microbe; this variation can be predominantly attributed to the difference in inactivation kinetics between the two species (known in the literature as RED Bias). RED bias is minimized when comparing microbes with similar UV sensitivity to each other. In this case, the data on MS2 inactivation will best represent that of more UV-resistant species, and the T1UV data will best represent more UV-susceptible. The wavelength dependence of inactivation kinetics should also be considered when considering microbe susceptibility.