watersprint
Intelligent water purification

ArrowMAX Home 10K UV-LED Water Disinfection System

This document presents a consolidated summary of third-party and internal validation results for the ArrowMAX Home 10K UV-LED disinfection system. The compiled data demonstrate the system's performance across a broad range of applications, including drinking water, wastewater, food and beverage processing, and related industrial uses, under both controlled laboratory conditions and real-world operating environments.

Validation testing was conducted by independent third-party laboratories and certification bodies, including IAPMO in accordance with NSF/ANSI 55 Class B requirements, GAPLAB EnviroMicrobial, as well as through field deployments with Watersprint partners and internal qualification testing. Collectively, these results confirm consistent, high-efficacy microbial disinfection performance across a wide range of flow rates and water quality conditions.

Powered by Watersprint's patented IntenseBeam™ Technology, the ArrowMAX Home 10K maximizes UV photon utilization to achieve industry-leading disinfection efficiency. Third-party certification testing, conducted by Biological Consulting Services of North Florida, Inc. and commissioned by IAPMO in accordance with the NSF/ANSI 55 protocol (Appendix A), confirms a minimum 2.9-log reduction (>99.87%) and an average 3.5-log reduction (>99.97%) of Q-β bacteriophage at the rated and certified flow rate. This performance exceeds NSF/ANSI 55 Class B requirements by an order of magnitude.

The system also demonstrated exceptional efficacy against clinically and operationally significant bacterial pathogens, including Pseudomonas aeruginosa and Legionella pneumophila, achieving greater than 6-log reduction (>99.9999%) at rated flow conditions, as documented in Appendix B.

Long-term testing of multiple ArrowMAX Home 10K units further confirms that this level of performance is maintained throughout the operational lifetime of the device. At end-of-life conditions (10,000 hours of active operation, equivalent to more than 10 years of typical residential use), the system consistently achieved complete inactivation of Escherichia coli (≥6-log reduction – complete elimination) across all tested flow rates up to 12 gallons per minute (45 L/min). Based on delivered UV dose measurements and established microbial inactivation thresholds (Appendix C), the ArrowMAX Home 10K is estimated to sustain ≥6-log bacterial reduction at flow rates up to 16 GPM (60 L/min) and ≥5-log reduction at flow rates exceeding 20 GPM (75 L/min), providing substantial performance headroom beyond standard residential, commercial, and light-industrial requirements.

Field case studies conducted in collaboration with Watersprint partners, summarized in Appendix D, further substantiate system performance under demanding real-world operating conditions, including severe microbial fouling downstream of filtration systems. In these deployments, the ArrowMAX Home 10K consistently achieved effective inactivation of iron-related bacteria and heterotrophic plate count (HPC) organisms, thereby restoring microbiological control in compromised water-quality environments. From a Hazard Analysis Critical Control Point (HACCP) perspective, this performance supports the system's role as a critical control measure for managing

biological hazards in food and beverage applications, particularly in installations where upstream filtration media may become a secondary source of microbial contamination.

Additional studies conducted in collaboration with the University of British Columbia confirm robust performance under low ultraviolet transmittance (UVT) conditions. Using MS2 bacteriophage as a surrogate organism, the system maintained a delivered UV dose exceeding 10 mJ/cm^2 at 10 GPM with UVT as low as 60%, corresponding to approximately 99.999% inactivation of bacteria such as E. coli, Pseudomonas, and Legionella. At moderate UVT levels (~90%), the delivered UV dose increased substantially to greater than 26 mJ/cm^2 , increasing to over 37 mJ/cm^2 at UVT = 98%, that can be typically maintained using common sediment filtrations.

In summary, the results presented herein demonstrate that the ArrowMAX Home 10K UV-LED disinfection system delivers superior, durable, and independently validated microbial inactivation performance. These attributes position the system as a best-in-class solution for residential, commercial, and light-industrial water treatment applications.

Figure 1 summarizes delivered reduction equivalent UV dose across a wide range of flow rates and UV transmittance conditions, derived from microbiological assay data and converted using established UV inactivation kinetics as referenced in Linden et al. (2009).

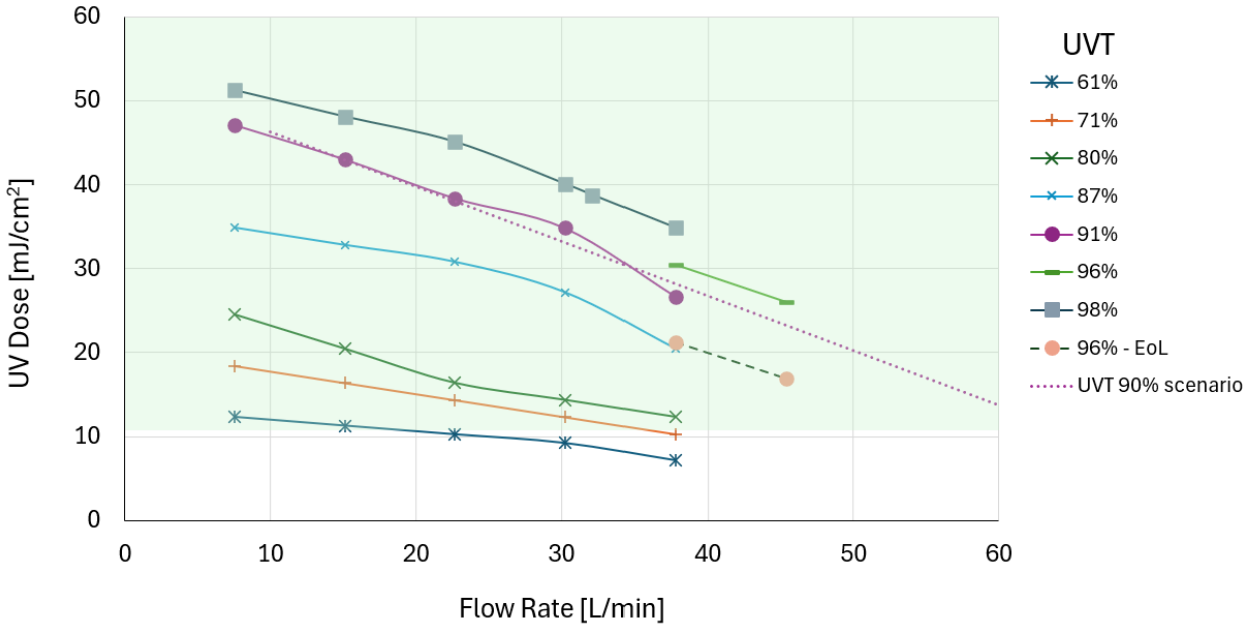


Figure 1: Summary of Third-Party (data points except 96% UVT and 96% - EoL, Watersprint internal test data) Test Results: Reduction Equivalent UV Dose Performance of the ArrowMAX Home 10K UV-LED Water Treatment Device Across a Range of Flow Rates and UV Transmittance (UVT).

Table 1: UV Dose Required for 4 LRV (99.99%) Inactivation of Common Microorganisms in Food & Beverage, and Food Processing Industries.

Pathogen	UV Dose (mJ/cm^2)	Reference
Bacteria		
Escherichia coli ATCC 11229	6.5	Sommer et al. 2000
Escherichia coli ATCC 11303	10.0	Wu et al. 2005
Escherichia coli ATCC 25922	8.0	Sommer et al. 1998
Escherichia coli O157:H7	6.0	Tosa & Hirata 1999
Escherichia coli - Wild type	8.1	Sommer et al. 2000
Legionella pneumophila ATCC 33152	7.7	Oguma et al. 2004
Legionella pneumophila ATCC 33823	5.8	Cervero-Aragó et al. 2014
Legionella pneumophila ATCC 43660	9.3	Wilson et al. 1992
Listeria monocytogenes	4.1	Collins 1971
Pseudomonas aeruginosa ATCC 27853	3.1	Clauß 2006
Pseudomonas aeruginosa ATCC 27853	7.5	Clauß 2006
Pseudomonas aeruginosa NCTC 10662	5.0	Blatchley et al. 2016
Salmonella spp. & ATCC 6539	7.0	Yaun et al. 2003 & Chang et al. 1985
Salmonella ATCC 19430	8.3	Wilson et al. 1992
Salmonella infantis	6.0	Tosa & Hirata 1998 (3-log)
Salmonella typhi ATCC 19430	8.2	Wilson et al. 1992
Shigella dysenteriae ATCC 29027	3.0	Wilson et al. 1992
Shigella sonnei ATCC 9290	8.2	Chang et al. 1985
Staphylococcus aureus ATCC 25923	10.0	Chang et al. 1985
Streptococcus faecalis ATCC 29212	11.1	Chang et al. 1985

Vibrio anguillarum	2	Liltved & Landfald 1996
Vibrio cholerae ATCC 25872	2.9	Wilson et al. 1992
Yersinia enterocolitica ATCC 27729	4.6	Wilson et al. 1992
Yersinia ruckeri	5	Liltved & Landfald 1996
Protozoa		
Cryptosporidium parvum	6	Amoah et al. 2005
Giardia spp.	3.4	Qian et al. 2004
Giardia lamblia	<1	Linden et al. 2002
Giardia muris	2.3	Hayes et al. 2003

The microbiological reduction performance of the ArrowMAX Home 10K system can be directly correlated with validated UV inactivation data summarized in Table 1. These data indicate a maximum required UV dose of 11.1 mJ/cm^2 to achieve greater than 99.99% (>4-log) inactivation of the microorganisms listed in Table 1, per the 4-LRV UV dose requirement indicated for Streptococcus faecalis (ATCC 29212), as reported by Chang et al. (1985). This inactivation threshold is consistent with UV dose recommendations established by the U.S. Environmental Protection Agency for food and beverage applications (EPA 815-R-20-003). As illustrated in Figure 1 (highlighted in green), the ArrowMAX Home 10K is capable of delivering this UV dose across a broad range of operating conditions, including variable flow rates and UVTs. For example, >99.99% reduction of all microorganisms listed in Table 1 can be achieved at flow rates up to 18 L/min (~4.5 GPM; ~1,000 L/h) at UVT values as low as 60%. Correspondingly, at higher water clarity of UVT ≥90%, which is still considered conservative, given NSF 55 requirements are prescribed at UVT ≥96%, the system can sustain such disinfection level at flow rates exceeding 60 L/min (~15 GPM; ~3,600 L/h), as denoted

by “UVT 90% scenario” in Figure 1, a condition that can be readily maintained in many applications using standard sediment filtration.

Importantly, this level of microbiological performance is maintained under end-of-life (EoL) operating conditions. The lifetime testing of ArrowMAX Home 10K device indicate an average of ~35% drop in UV dosage throughout the active 10,000 hours of operation. Under these conditions, the system continues to deliver a validated UV dose sufficient to achieve ≥99.99% (>4-log) inactivation of the microorganisms listed in Table 1, with an appropriate design margin, at flow rates up to 45 L/min (12 GPM; ~2,700 L/h) at a UVT of 96%/cm. This performance is consistent with the conservative design principles and dose-based validation approaches referenced by the U.S. Environmental Protection Agency and NSF/ANSI guidance for UV disinfection systems, which emphasize verified minimum delivered dose at EoL and under worst-case operating conditions. UVT levels of this magnitude are readily achievable and maintainable through standard upstream filtration practices commonly employed in residential and light-commercial water treatment applications.

To relate the abovementioned performance data to microbial disinfection efficacy across a range of organisms, the operating envelope presented in Figure 1 can be combined with validated, peer-reviewed UV dose response (inactivation kinetics) data. Under a conservative operating scenario, assuming a maximum flow rate of 2,000 L/h (~8.8 GPM; ~33 L/min) and a representative UVT of 90%/cm, the delivered UV dose can be derived directly from Figure 1. When further accounting for an estimated cumulative UV output degradation of approximately 35% over the active 10,000 hour operating life of the system, consistent with EPA and NSF-referenced end-of-life design

considerations, the ArrowMAX Home 10K is calculated to maintain a minimum delivered UV dose of approximately 20 mJ/cm^2 at the end of device life. This delivered UV dose exceeds the minimum UV dose required to achieve >99.99% (>4-log) inactivation of all microorganisms listed in Table 1 by a factor of two, thereby providing a 100% UV dose safety margin under conservative, worst-case operating conditions. The corresponding log reduction values associated with this UV dose are summarized in Appendix E, based on organism specific UV inactivation kinetics reported by Bolton et al. (2016).