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technical BRIEF
INNOVATIVE RESEARCH FOR A SUSTAINABLE FUTURE

Testing and Evaluation of the Solstreme™ X35 ™ Portable UV Water Treatment Unit

Introduction

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) identifies and tests portable water treatment technologies that can be utilized for water disinfection and decontamination operations in support of emergency response. Optimally, the equipment should be easy to use by emergency responders, should be easy to transport in a standard pick-up truck (48 by 60 inches) (English units are used throughout this report except for light intensity and dosage units) and should not require a forklift for loading or off-loading. EPA does not provide any endorsement of these technologies.

The Solstreme™ X35 ™ultraviolet (UV) germicidal water treatment unit first appeared on the market as a commercial product in 2013. The Solstreme X35 unit uses a patented microwave-actuated electrodeless lamp technology to provide UV disinfection. The electrodeless lamps can be run at higher power levels than electrode-based lamps, allowing them to produce greater amounts of UV light. Electrode-based lamps conform to the National Sanitation Foundation (NSF) Standard 55 "Class A" Rated UV systems specifications, which require operation at a minimum UV light dosage of 40 mJ/cm² (millijoules/cm^2), which is equivalent to 40 mW-sec/cm^2 (intensity [milliwatts/cm^2] × sec) (USEPA, 2003). The manufacturer expects the electrodeless Solstreme X35 unit operating under optimal conditions to deliver an equivalent total dosage of up to 1,700 mW-sec/cm^2 (NeCamp, 2008). However, the design of the X35 unit makes it difficult to verify the dosage. The Solstreme X35 manufacturer has developed conversion tables to correlate the flow rate and power settings (1 through 5) to UV dosage. See Appendix 1.

The Solstreme X35 unit was originally designed for use in developing countries that are without access to dependably safe water supplies. The unit was made to be portable (approx. 75 lbs) for delivery to remote communities and to treat any form of raw water that has been treated with adequate pre filtration (50 to 100 microns). The unit uses a patented process and materials to focus the UV waves such that doses as high as 120 mJ/cm^2 can be achieved with this compact size unit. The unit is locally supported by the Solstreme company in Cincinnati, Ohio. The X35 unit as tested by EPA costs approximately $15,000 with another $1000 needed for sampling equipment and install and set up. The lamp life is three years.

Initial Solstreme X35 unit testing against *Bacillus globigii* at EPA's T&E Facility, June 2015

The Solstreme X35 unit was initially tested against *Bacillus globigii,* a surrogate for *Bacillus anthracis,* in June 2015 at EPA's Test and Evaluation (T&E) Facility in Cincinnati, Ohio. The testing was done on the 3-inch line drinking water distribution system simulator (DSS), which consists of approximately 1200

feet of piping. Tap water from the Greater Cincinnati Water Works (GCWW) is pumped through the DSS where contaminants can be injected. See USEPA, 2009, for a complete description of the DSS.

This experiment was conducted using a flow rate of 8 gallons per minute (gpm) through the DSS. Chlorinated tap water enters the T&E Facility directly from the GCWW distribution system and flows into a 1,000-gallon tank located on the floor of the facility. The water is then pumped to an elevated 750-gallon storage tank and gravity-fed to the DSS. The water from the 750 gallon tank was injected with over 10 million colony forming units (CFU) of *B. globigii* as it exited the DSS and was plumbed directly into the Solstreme X35 unit as shown in Figure 1.

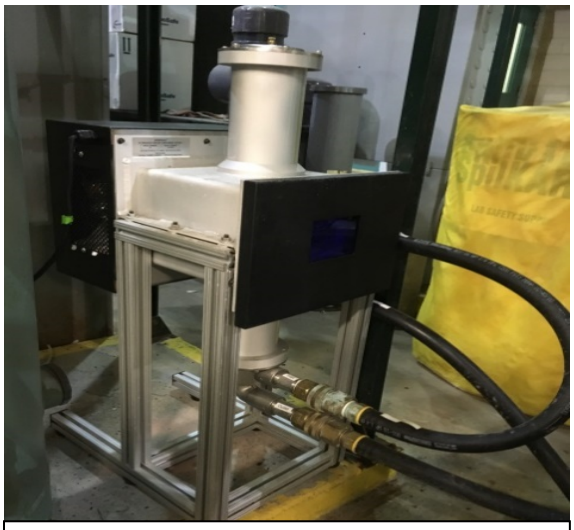

Figure 1. Solstreme™ X35 ™ unit set up at EPA's T&E Facility (vertical cell).

The lamp intensity during the time frame that the slug passed through the unit ranged from 55–64 Solstreme units (SU). Solstreme Units (SU) were derived by the manufacturer. Conversion tables are provided by the manufacturer in Appendix 1 for 5 average UV dosages. With an optimal flow rate of 8 gpm and an observed Solstreme reading of 55 to 64, the dosage of 158 mJ/ sq cm corresponds to a destruction percent of 99.999 or a 5-log reduction based upon MS2 coliphage inactivation.

Table 1 summarizes the results from the *B. globigii* analysis of water samples collected during this study. The average concentration of *B. globigii* from the inlet samples collected was approximately 23 million CFU/100 mL. Individual inlet concentrations were compared to the outlet concentrations in order to compute the log reduction values shown in Table 1. The results indicate that the X35 unit was very effective (up to 6.9-log reduction) at inactivating *B. globigii* which was better than the Appendix 1 tables based upon MS2 coliphage inactivation predicted.

Table 1: *Bacillus globigii* Disinfection and UV Exposure Time (Based on Exposure to the Solstreme™ X35 Unit)

SAMPLE ID (Exposure time)	Average Solstreme™ X35 Inlet *B. globigii* concentration CFU per 100 mL	Solstreme™ X35 Outlet *B. globigii* concentration CFU per 100 mL	Log reduction
Pretest/baseline	0.00E+00	0.00E+00	-
10 minutes	2.33E+07	1.37E+02	5.2
15 minutes	2.33E+07	6.00E+01	5.6
20 minutes	2.33E+07	1.05E+02	5.3
25 minutes	2.33E+07	2.60E+01	6.0
30 minutes	2.33E+07	3.00E+00	6.9

Experiment Design at Idaho National Lab

Based upon the promising results of the Solstreme X35 unit testing at the T&E facility in Cincinnati, EPA decided to test the X35 unit on a full-scale replica of a drinking water distribution system, the water security test bed, at the Idaho National Laboratory. This Idaho water security test bed (WSTB) experiment was designed to assess the ability of a portable disinfection unit to treat a large volume of water contaminated with *B. globigii* spores. When disinfectant is added to contaminated water, it reacts with the microbes, but also with other impurities in the water. So the demand on the disinfection agent by other impurities must be met, and there must be a sufficient residual disinfectant concentration to effectively treat the microbial contaminants. The water in the lagoon contained dirt and sediment from the surrounding area, as well as algae. The dirt and algal growth created a disinfectant demand in the water and rendered the water "dirty." The X35 unit was tested along with 4 other technologies for the ability to treat this dirty water contaminated with spores.

The effectiveness of the Solstreme™ X35 unit was evaluated by sampling water contaminated with *B. globigii* spores before it entered the unit, before treatment began, and then after disinfection to determine the treatment effectiveness. The concentration of spores in the influent (or before treatment began) was then compared to the concentration in the effluent (after treatment). The matrix water for the X35 unit experiment was pumped from the lagoon into a 2,000-gallon flexible bladder tank. The spores were added to the filled bladder tank, which contained a mixing pump to ensure a continuous stream of *B. globigii* spores were provided to the treatment unit (Figure 2).

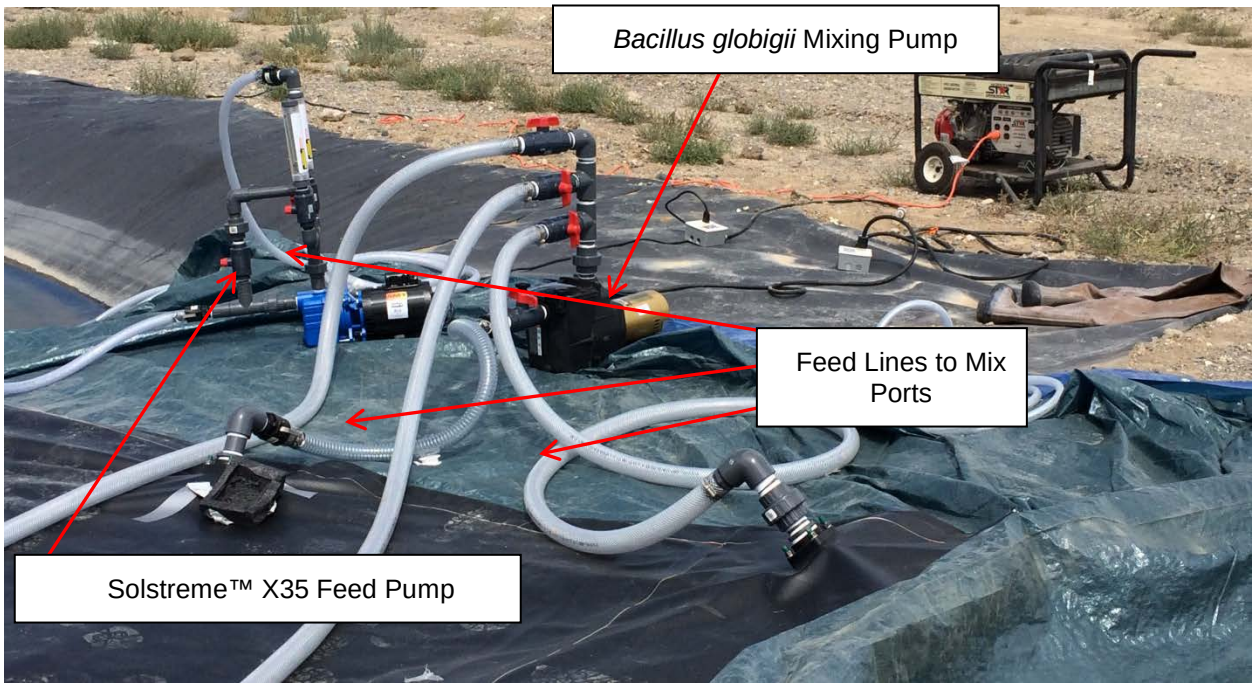

Figure 2. Inlet bladder tank and mixing.

Figure 3 shows a schematic depiction of how the mixing pump was connected to the bladder to perform mixing along with the inlet and outlet ports.

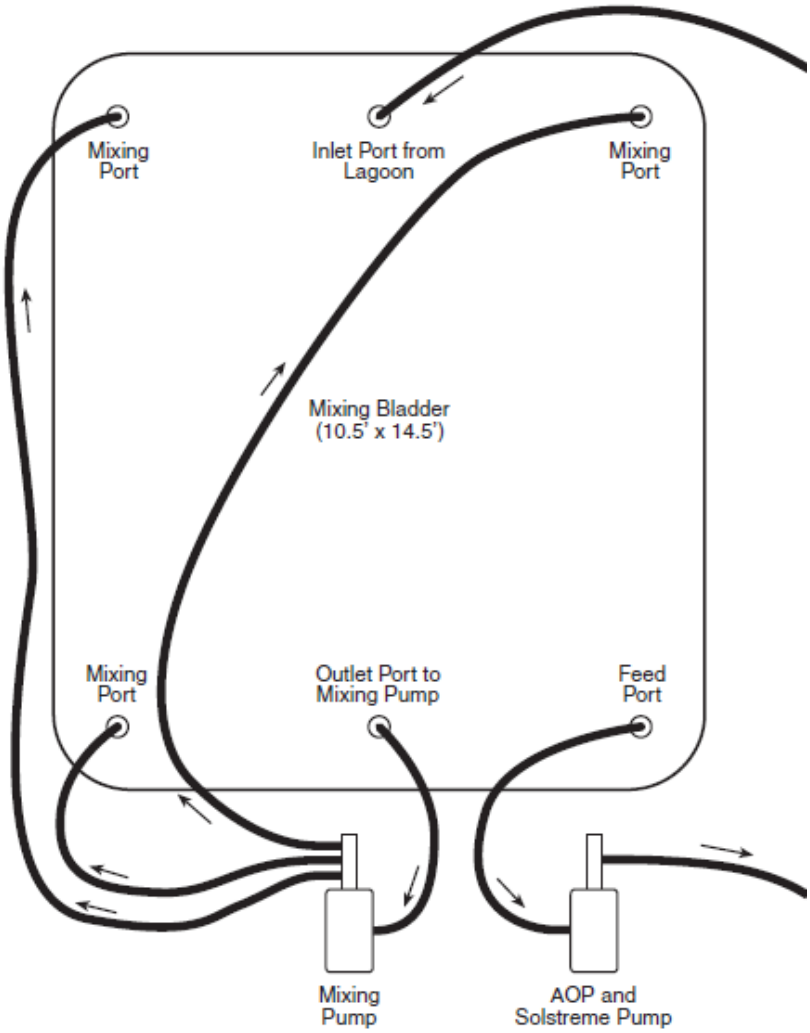

Figure 3. Schematic depiction of the inlet bladder tank mixing process. (Source: U.S. EPA. 2016. *Testing large volume water treatment and crude oil decontamination using the Water Security Test Bed at the Idaho National Laboratory*. EPA/600/R-161/126)

For the Solstreme X35 unit, a target inlet concentration of greater than 10^6 spores/100 mL (or 10^4 spores/mL) was prepared using the inlet bladder tank and mixing pump shown in Figure 3. The water was then pumped to the treatment unit. The X35 unit was tested for 5.5 hours. Pre-treatment and post-treatment water samples for *B. globigii* analysis were collected at the same time.

Idaho Field Testing of the Solstreme™ X35 Unit

In 2015, the large volume disinfection study using Solstreme X35 unit, was performed at the WSTB at the Idaho National Laboratory in Scoville, Idaho. The X35 unit setup is depicted in Figure 4.

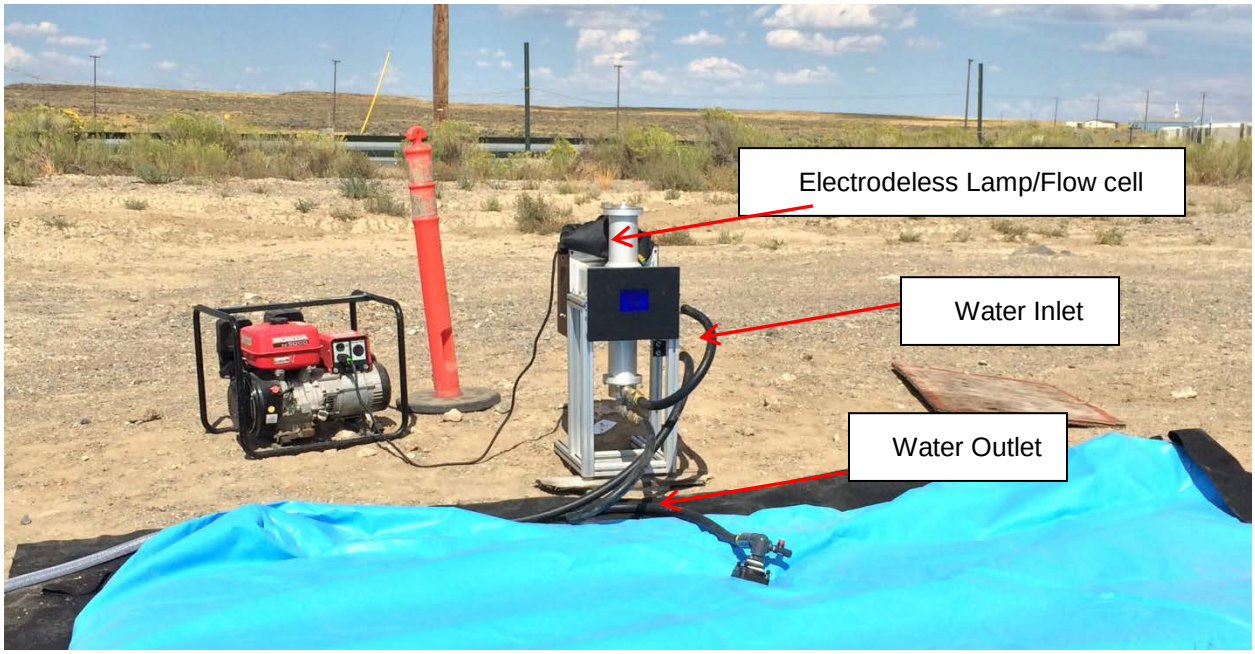

Figure 4. Solstreme™ X35 UV unit and effluent bladder tank (blue object in front of the UV system).

The baseline water sample (BWS) for *B. globigii* concentrations (BWS-0 through BWS-6, time points over a 5.5-hour duration) were collected from the inlet and outlet of the system simultaneously using the grab sampling technique in 100-mL sterile sample bottles with a 10 mg sodium thiosulfate tablet. The sodium thiosulfate was used to eliminate any remaining chlorine in the samples so the true cell density of the bacteria could be enumerated. The BWS sampling ports at both inlet and outlet of the system were opened, and the water was drained for 15 seconds prior to collection of the sample.

Idaho Field Test Results for Solstreme™ X35 Unit Testing

The Solstreme X35 unit disinfects water through UV light only. Figure 5 shows the X35 unit's influent spore density (blue bars) and the density of spores in the treated effluent (orange bars). Influent and effluent samples were taken simultaneously, so the difference between the bars at each time point represents the amount of spore inactivation taking place, or log reduction (green line) at that point in time. The influent spore density, over the course of the experiment, was approximately 1.6×10^5 CFU/ml. This was a positive finding since a consistent influent concentration was desired over the course of the experiment.

The effluent spore densities from the Solstreme X35 unit consistently decreased as the experiment progressed. A corresponding increase in spore log reduction over the course of the experiment was also observed. After discussing this finding with the X35 unit's manufacturer, a possible reason for this increase in disinfection performance emerged. The X35 unit's UV output is higher at higher temperatures. Over the course of the experimental period (from early morning to mid-afternoon), the air and lagoon water temperature at the test site increased from 12° to 28°C and from 15° to 25°C, respectively. It should be noted that no free-chlorine residual was detected in the water.

Figure 6 shows the log reduction data from Figure 5 plotted against the output intensity from the Solstreme X35 unit over the course of the experiment. The X35 unit's output intensity is a unitless measure of the UV output derived by the manufactured called Solstreme Units (SU). Typically, for an electrode-based UV bulb, the intensity is measured in mill watts per square centimeter (mW/cm^2).

However, the electrodeless design of the X35 unit does not allow for direct conventional radiometer-based UV intensity measurements. Figure 6 provides an indirect measure of the UV intensity based on achievement of 3.5- to 4-log inactivation of *B. globigii* spores in lagoon water with ~11 to 13 NTU turbidity (pH of approximately 7.5). This turbidity was higher than the initial X35 unit's testing against *Bacillus globigii* at T&E facility in 2015, which was well below 1 NTU. See EPA Wastewater technology fact sheet EPA 832-F-99-064

The increase in output intensity of the Solstreme X35 unit in Figure 6 is perhaps due to the increase in water temperature over the course of the experiment. In the future, it may be beneficial to add a heating element to the X35 unit's influent water line to bring water to a temperature between 25° to 30°C and a pre-filter to reduce the disinfection demand in the water. Increased disinfection may be due to hydroxyl radical formation due to photolysis of the water with higher temperature. The influence of air and water temperature on disinfection performance merits further investigation.

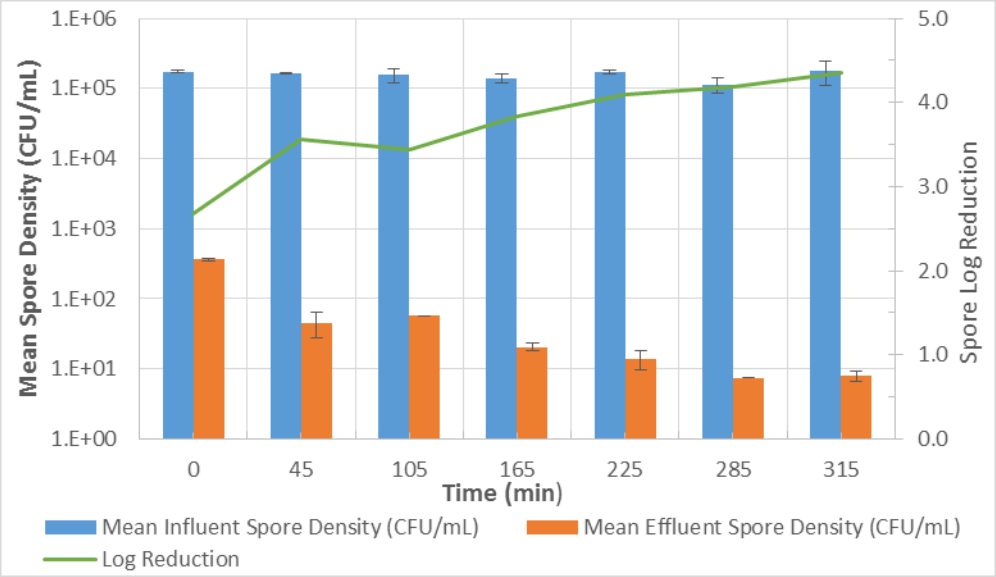

Figure 5. Treatment performance of the Solstreme™ X35 unit over the course of 5.5 hrs.

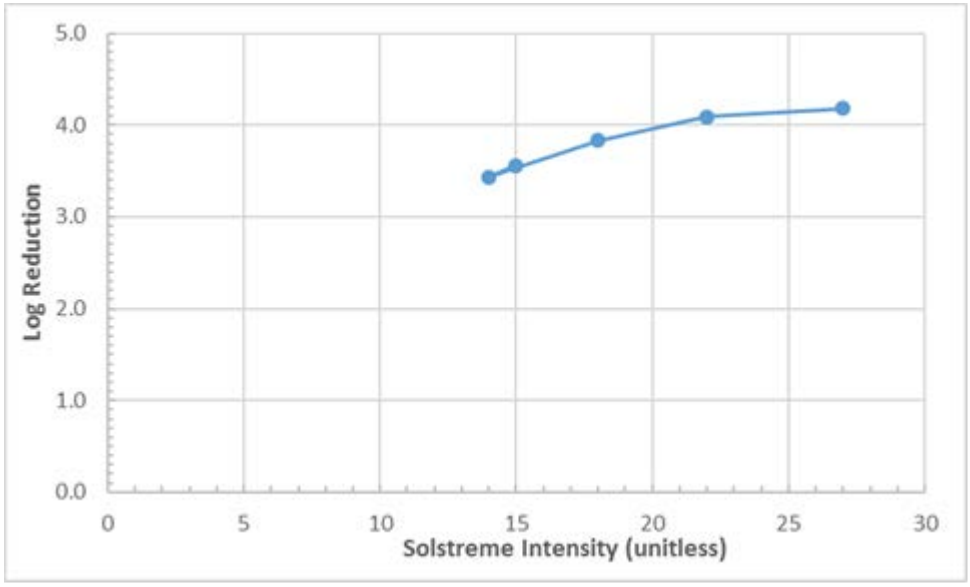

Figure 6. Spore log reduction for Solstreme™ X35 UV unit treatment vs. UV output intensity. Solstreme™ X35 unit output intensity is a proprietary, unitless measure of UV intensity.

Table 2 contains a summary of the Solstreme X35 unit's performance results from Idaho. The X35 unit performed well in the field where log reductions of 3.5 to 4.0 were observed. The X35 unit achieved an average spore log reduction of 3.7, with log removal increasing from 3.0 to 4.0 over the course of the 5.5 hr. experiment. This increase could have been due to the increase in temperature experienced during the daylight hours elevating the UV output/efficiency and leading to greater disinfection. Two thousand gallons of water were treated during the experimental run. However, due to the differences discussed above, it did not achieve the over 6-log reduction observed at the T&E facility lab setting. For the full report on the performance of the Solstreme™ X35 unit and three other water treatment technologies at the Idaho National Lab, please see USEPA, 2016.

Table 2. Mobile Water Treatment Unit Performance Summary

Water Treatment Technology Tested	Capital Cost	Average Log Reduction	Volume Treated (gal)	Flow (gpm)	Performance Summary
Solstreme™ X35 (UV)	$15,000	3.5 to 4.0	2,000	5	Stable, immediate disinfection, easy to transport and set up.

X35 testing against *Escherichia coli* at T&E

Since EPA had previously determined the performance of the Solstreme X35 unit in the lab and in the field against *Bacillus globigii*, the researchers decided to challenge the X35 with another bacterial contaminant, *Escherichia coli*, at the T&E facility in 2017. This experiment was also conducted using a flow rate of 8 gallons per minute (gpm) through the DSS. As with the previous *B. globigii* study at T&E, chlorinated tap water entered the T&E Facility directly from the GCWW distribution system and flowed into a 1,000-gallon tank located on the floor of the facility. The water was then pumped to an elevated 750-gallon storage tank, and gravity-fed to the DSS. Prior to and during the entire test, the contents of the 750-gallon storage tank were dechlorinated using sodium thiosulfate. The sodium thiosulfate solution was continually pumped into the storage tank using a chemical feed pump. This was done to prevent the *E. coli* from being killed by the residual chlorine from Cincinnati tap water, which would have confounded the results for the X35 unit's inactivation testing. Complete dechlorination through the DSS was confirmed by continuous online readings from a Hach® Cl-17 free-chlorine analyzer (Hach, Loveland, CO) and grab samples analyzed by the Hach DPD (N,N diethyl-1,4 phenylenediamine sulfate) method. The *E. coli* was injected into the dechlorinated water exiting the 750-gallon tank and was plumbed directly into the X35 unit as previously shown in Figure 1.

The flow of *E. coli*-contaminated water through the Solstreme X35 unit was maintained at 8 gpm using an inline control valve and rotameter combination. The observed lamp intensity during the injection period ranged from 65–74 Solstreme units. The manufacturer supplied conversion tables in Appendix 1 provide a dosage value of 210 mJ/cm sq. based on an optimal flow rate of 8 gpm at observed intensities of 65 to 74 SU. The average UV dosage of 210 mJ/cm sq. corresponds to a destruction percent of 99.9999 or a 6-log reduction based upon MS2 coliphage inactivation. (See Appendix 1)

Table 3 summarizes the results from the *E. coli* analysis of water samples collected during this study. The average concentration of *E. coli* which was injected into the pipe flowing into the Solstreme unit was 5.70E+06 CFU/100 mL. Individual inlet concentrations were compared to the outlet concentrations in order to compute the log reduction values shown in Table 3. The results indicate that the X35 unit was very effective (consistent 6-log reduction) at inactivating *E. coli* which was the response predicted from the MS2 coliphage tables in appendix 1.

Table 3: Summary of *Escherichia coli* Disinfection Results (based on exposure to the Solstreme™ X35 unit)

SAMPLE ID	Solstreme™ X35 unit's Inlet *E. coli* concentration CFU per 100 mL	Solstreme™ X35 unit's Outlet *E. coli* concentration CFU per 100 mL	Log reduction
Pretest/baseline	0.00E+00	0.00E+00	-
15 minutes	6.13E+06	0.00E+00	6
30 minutes	6.87E+06	0.00E+00	6
45 minutes	6.87E+06	0.00E+00	6
60 minutes	2.91E+06	0.00E+00	6

Testing of the UVLS 1000 unit against *Escherichia coli* at T&E

In 2017, the inventor and patent holder of the Solstreme X35 unit contacted EPA about a prototype next-generation Solstreme X35 unit to be sold as the UVLS-1000 unit. This unit is capable of treating drinking water at a flow rates of up to 20 gallons per minute with the approximate same weight and shape as the X35 unit per the manufacturer. This prototype unit also has the ability to operate at seven different UV power levels. The Solstreme™ X35 UVLS-1000 unit used in this evaluation at the T&E Facility had two different configurations – one with the UV cell in the horizontal position and the other with the UV cell in the vertical position (Figures 7 and 8). The effect of air pockets and bubbles in the flow cell can reduce decontamination efficiency so the flow cell can be oriented horizontally or vertically.

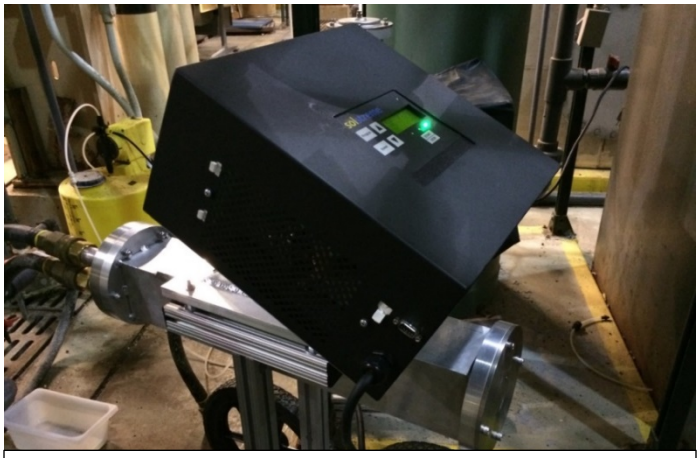

Figure 7. Solstreme™ X35 UVLS-1000 Device (Horizontal Cell).

Figure 8. Solstreme™ X35 UVLS-1000 Unit.

Five test runs were made with the UVLS-1000 unit at two flow cell configurations (horizontal and vertical) and two power settings (1 and 7) with various flow rates from 5 to 11 gpm as shown in Table 4.

Throughout the tests, as the *B. globigii* slug was passing through the device, the UV intensity of the prototype unit was recorded. Table 4 presents the observed UV intensity range (in SU units) for each test during the time period that the slug was passing through the device.

Results of T&E testing of UVLS 1000

Table 4 summarizes the results from the *B. globigii* analysis of water samples collected during these tests. Individual inlet concentrations were compared to the corresponding outlet concentrations in order to compute the log reduction values. Samples were taken prior to injection and, 5, 10 and 15 min after injection. The baseline or prior sample does not return to zero for tests 2, 3 ,4, and 5 because the line was just flushed between tests and the residual *B. globigii* requires higher concentrations of chlorine to return to zero.

Table 4: Summary of *Bacillus globigii* Disinfection Results for Solstreme™ X35 UVLS-1000 Unit

Configuration	SAMPLE ID	Flow Rate, gpm	Power Level	UV Intensity Range (mJ/sq cm)	Unit's inlet *B. globigii* concentration CFU/100 mL	Unit's outlet *B. globigii* concentration CFU/100 mL	Log reduction
Horizontal Cell	**Test 1**	11	1	128-139			
	1-1 (background)				0.0E+00	0.0E+00	-
	1-2 (5 min)				6.3E+07	1.0E+04	3.8
	1-3 (10 min)				6.4E+07	8.2E+03	3.9
	1-4 (15 min)				6.4E+06	3.4E+02	4.3
	Test 2	**8**	**1**	**122-132**			
	2-1 (background)				1.7E+04	5.0E+01	2.5
	2-2				1.4E+08	5.6E+03	4.4
	2-3				2.0E+08	6.8E+03	4.5
	2-4				2.6E+08	3.1E+03	4.9
	Test 3	5	1	130-140			
	3-1 (background)				1.9E+04	0.0E+00	4.3
	3-2				6.3E+07	1.0E+03	4.8
	3-3				7.3E+08	3.1E+03	5.4
	3-4				4.9E+08	3.0E+03	5.2
Vertical Cell	Test 4	5	7	185-203			
	4-1 (background)				2.7E+03	0.0E+00	3.4
	4-2				1.7E+07	1.3E+03	4.1
	4-3				2.6E+07	1.8E+03	4.2

Configuration	SAMPLE ID	Flow Rate, gpm	Power Level	UV Intensity Range (mJ/sq cm)	Unit's inlet *B. globigii* concentration CFU/100 mL	Unit's outlet *B. globigii* concentration CFU/100 mL	Log reduction
	4-4				6.4E+07	3.4E+03	4.3
	Test 5	10	7	195-205			
	5-1 (background)				1.1E+04	5.0E+00	3.3
	5-2				1.2E+07	7.0E+03	3.2
	5-3				1.5E+07	5.7E+03	3.4
	5-4				1.9E+07	6.4E+03	3.5

As shown in Table 4 , *B. globigii* spores were present in most of the outlet samples as the *B. globigii* slug passed through the prototype Solstreme™ X35 UVLS-1000 unit. Comparing inlet and outlet concentrations, the UVLS-1000 unit, in the horizontal position at power level 1, demonstrated a maximum log reduction of 4.3 operating at 11 gpm, 4.9 operating at 8 gpm flow, and 5.4 operating at 5 gpm. In the vertical position at power level 7, the UVLS-1000 unit demonstrated a maximum log reduction of 4.3 operating at 5 gpm and 3.5 operating at a 10 gpm flow.

Conclusions

The Solstreme™ X35 unit overall was able to consistently disinfect *E. coli* contamination to over 6 log reductions. The technology was able to consistently inactivate *Bacillus globigii* spores from 3.5 to 5.0 log reductions at flow rates from 5 to 11 gpm. These positive results warrant further use and testing by emergency response personnel in the field. The X35 unit is light weight and can be transported easily to the site of an emergency response. The unit is easy to use and can be quickly connected to contaminated water and begin disinfection in a self-contained treatment unit. This technology can be operated via standard 120-volt electrical service or a portable generator.

The prototype UVLS 1000 unit did not demonstrate improved spore inactivation performance from the Solstreme™ X35 unit previously tested against *Bacillus* spores at the T&E facility and was only slightly better than the X35 unit tested at the water security test bed in Idaho. The influence of turbidity, air pockets, and water temperature affects disinfection performance and merits further investigation for this particular unit.

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Appendix 1.

Table A1. Prototype Solstreme™ X35 ™ULVS-1000 Unit's Calculated Dosages Based on MS2 Coliophage Inactivation

					UV Treatment Data				
						Calculated *			
Date	Time	Sample	Description	Flow Rate (GPM)	Observed Intensity (SU)	Intensity (mW/cm²)	Exposure (sec)	Dosage (mJ/cm²)	Log Reduction
Horizontal Configuration Power Level 1									
11-Jul-17	10:40	Outlet 1-1	Background Sample - treated/ no BG	11.0	137	177	2.18	386	0
11-Jul-17	11:44	Outlet 1-2	UV Treated - BG	11.0	128	165	2.18	360	3.8
11-Jul-17	11:46	Outlet 1-3	UV Treated - BG	11.0	130	168	2.18	367	3.9
11-Jul-17	11:51	Outlet 1-4	UV Treated - BG	11.0	133	172	2.18	375	4.3
11-Jul-17	12:55	Outlet 2-1	Background Sample - treated/ no BG	8.0	131	169	3.00	507	2.5
11-Jul-17	14:03	Outlet 2-2	UV Treated - BG	8.0	125	161	3.00	483	4.4
11-Jul-17	14:08	Outlet 2-3	UV Treated - BG	8.0	125	161	3.00	483	4.5
11-Jul-17	14:13	Outlet 2-4	UV Treated - BG	8.0	122	157	3.00	471	4.9
12-Jul-17	9:56	Outlet 3-1	Background Sample - treated/ no BG	5.0	139	179	4.80	859	4.3
12-Jul-17	11:34	Outlet 3-2	UV Treated - BG	5.0	131	169	4.80	811	4.8
12-Jul-17	11:37	Outlet 3-3	UV Treated - BG	5.0	130	168	4.80	806	5.4
12-Jul-17	11:40	Outlet 3-4	UV Treated - BG	5.0	131	169	4.80	811	5.2
Vertical Configuration Power Level 7									
18-Jul-17	10:09	Outlet 4-1	Background Sample - treated/ no BG	5.0	203	262	4.80	1257	3.4
18-Jul-17	11:44	Outlet 4-2	UV Treated - BG	5.0	189	244	4.80	1170	4.1
18-Jul-17	11:49	Outlet 4-3	UV Treated - BG	5.0	186	240	4.80	1152	4.2
18-Jul-17	11:54	Outlet 4-4	UV Treated - BG	5.0	185	239	4.80	1146	4.3
18-Jul-17	13:25	Outlet 5-1	Background Sample - treated/ no BG	10.0	202	261	2.40	625	3.3
18-Jul-17	14:20	Outlet 5-2	UV Treated - BG	10.0	195	252	2.40	604	3.2
18-Jul-17	14:25	Outlet 5-3	UV Treated - BG	10.0	195	252	2.40	604	3.4
18-Jul-17	14:30	Outlet 5-4	UV Treated - BG	10.0	197	254	2.40	610	3.5

*Intensity and dosage computations are based on Solstreme's testing with MS2 Coliophage.

Bg, *Bacillus globigii*; gpm, gallons per minute; UV, ultraviolet

Units: mJ/cm^2, millijoules/square centimeter; mW/cm^2, milliwatts/sqare centimeter; sec, seconds of exposure in device; SU, Solstreme Units;

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Table A2. Manufacturer Supplied Log Reduction Conversion Table for Solstreme Units (SU) Versus Max Flow at 5 Dosage Settings Based on MS-2 Coliphage Inactivation.

Optimal Flow Rate - GPM

MS2 Coliphage Inactivation Guidelines	
Destruction %	X35 Unit Dosage
99.99	126
99.999	158
99.9999	210
99.99999	264
99.999999	310

UV Dosage	126
Safety Factor	0.1
Intensity (X35 Scale)	Max Flow Rate (GPM)
6	1.0
9	1.5
12	2.0
15	2.5
18	3.0
21	3.5
24	4.0
26	4.5
29	5.0
32	5.5
35	6.0
38	6.5
41	7.0
44	7.5
47	8.0
50	8.5
52	9.0
55	9.5
58	10.0
61	10.5
64	11.0
67	11.5
70	12.0
73	12.5
76	13.0
78	13.5
81	14.0
84	14.5
87	15.0

UV Dosage	158
Safety Factor	0.1
Intensity (X35 Scale)	Max Flow Rate (GPM)
8	1.0
11	1.5
15	2.0
19	2.5
22	3.0
26	3.5
29	4.0
33	4.5
37	5.0
40	5.5
44	6.0
48	6.5
51	7.0
55	7.5
58	8.0
62	8.5
66	9.0
69	9.5
73	10.0
77	10.5
80	11.0
84	11.5
87	12.0
91	12.5
95	13.0
98	13.5
102	14.0
106	14.5
109	15.0

UV Dosage	210
Safety Factor	0.1
Intensity (X35 Scale)	Max Flow Rate (GPM)
10	1.0
15	1.5
20	2.0
25	2.5
29	3.0
34	3.5
39	4.0
44	4.5
49	5.0
53	5.5
58	6.0
63	6.5
68	7.0
73	7.5
77	8.0
82	8.5
87	9.0
92	9.5
97	10.0
102	10.5
106	11.0
111	11.5
116	12.0
121	12.5
126	13.0
130	13.5
135	14.0
140	14.5
145	15.0

UV Dosage	264
Safety Factor	0.1
Intensity (X35 Scale)	Max Flow Rate (GPM)
13	1.0
19	1.5
25	2.0
31	2.5
37	3.0
43	3.5
49	4.0
55	4.5
61	5.0
67	5.5
73	6.0
79	6.5
85	7.0
91	7.5
97	8.0
103	8.5
109	9.0
115	9.5
121	10.0
128	10.5
134	11.0
140	11.5
146	12.0
152	12.5
158	13.0
164	13.5
170	14.0
176	14.5
182	15.0

UV Dosage	310
Safety Factor	0.1
Intensity (X35 Scale)	Max Flow Rate (GPM)
15	1.0
22	1.5
29	2.0
36	2.5
43	3.0
50	3.5
57	4.0
64	4.5
72	5.0
79	5.5
86	6.0
93	6.5
100	7.0
107	7.5
114	8.0
121	8.5
128	9.0
135	9.5
143	10.0
150	10.5
157	11.0
164	11.5
171	12.0
178	12.5
185	13.0
192	13.5
199	14.0
207	14.5
214	15.0