LOW- AND MEDIUM-PRESSURE UV PERFORMANCE VERIFICATION

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ABSTRACT

The NSF/EPA Environmental Technology Verification (ETV) Center provides independent performance evaluations of drinking water technologies to accelerate a technology's entrance into the commercial marketplace by providing consumers with verified results of product evaluations. Two EPA/NSF ETV Program reports were recently prepared to verify the performance of one low pressure (Atlantic Ultraviolet Corporation) and one medium pressure (Trojan Technologies) ultraviolet (UV) system. Testing was conducted at the City of San Diego's Aqua 2000 Research Center located in Chula Vista, California, using treated Otay Lake filtered water as feedwater. Otay Lake water is characterized by relatively high hardness and pH values, which can contribute to scaling/fouling of the lamp sleeves, and has elevated levels of organic material, which can result in low transmittance. At 100% lamp power, UV_{254} transmittance of 90.6% the low-pressure system was able to inactivate 1.2 to 2.1 logs of MS2 virus at 350 gpm. The medium pressure system was able to inactivate 2.1 to 3.0 logs of MS2 virus at 695 gpm, with the lamp power set at 81% and a UV_{254} transmittance of 84%.

INTRODUCTION

Rapid developments in regulatory requirements as well as the identification of emerging pollutants and pathogens, have resulted in the need to install new treatment technologies that lack historical performance data. In order for regulatory agencies to approve the design and installation of these new technologies, however, manufacturers must be able to provide independent third-party verification of their performance claims. Frequently, the process design and installed system performance must also be validated through an approved field commissioning study.

In order to meet the control requirements specified for Cryptosporidum parvum in the draft Stage 2 Long-Term Enhanced Surface Water Treatment Rule (LT2ESWTR) and the disinfection byproduct reduction requirements of the draft Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR), many water agencies have begun design and construction of ultraviolet light (UV) facilities. Although the application of UV has been integrated into the list of technologies available for wastewater disinfection, new developments in lamp technology and reactor design, water quality differences between water and wastewater, and the heightened sensitivity of the public to drinking water issues, has prevented the direct translation of historical wastewater performance data to the drinking water field. Consequently, drinking water systems will require a significant level of testing in order to demonstrate that they fulfill the manufacturers' claims about dose delivery, process control, system reliability, and long-term performance.

NSF International (NSF), in partnership with the United States Environmental Protection Agency (USEPA) provides independent performance evaluations of drinking water technologies through the Environmental Technology Verification (ETV) Program. The purpose of this program is to accelerate a technology's entrance into the commercial marketplace by providing consumers with independent third-party verifications results of product evaluations. The USEPA is presently developing a UV Disinfection Guidance Manual to provide assistance in the design, testing, and operation of UV systems for compliance with drinking water disinfection requirements.

MATERIALS AND METHODS

NSF published the first verification testing of UV technology in May 1999 for a medium-pressure Calgon Carbon Corporation Sentinel Ultraviolet Reactor. Two new systems have been passed through the ETV program. Pictures of each system, are shown in Figure 1, Trojan Technologies UVSwift Model 4L12, and Figure 2, Atlantic UV Megatron Model M250.

The Trojan Technologies UVSwift 4L12 contained four 2.8 kilowatt medium pressure UV lamps perpendicular to flow and the unit had flanged fittings for in-line mounting in 12-inch pipe. The system also included a proprietary flow-modifying baffle plate that mounted on the inlet to the reactor. The unit included one UV irradiance sensor that measured the output from one lamp and could be verified against a calibrated reference sensor.

The Atlantic UV Megatron M250 consisted of a 12-in diameter stainless steel chamber which contained nineteen (19)

G64T5L low-pressure lamps stacked in a configuration of three lamps per cleaning assembly with total lamp power of 1235 W (65 W per lamp). The lamps were oriented parallel to flow and each lamp had one power setting (100% lamp output). The unit included one UV irradiance sensor that measured the output from one of the nineteen lamps and could be verified against a calibrated reference sensor.

Figure 1. *Installation of Trojan Technologies UVSwift 4L12 Unit*

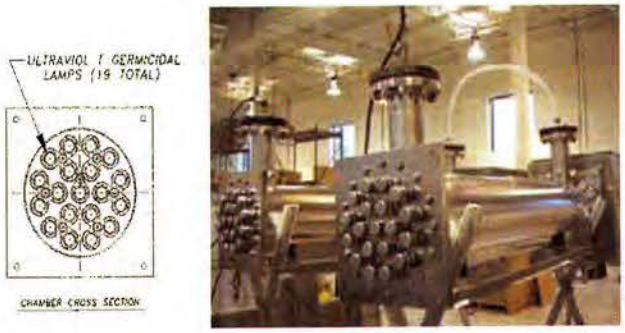

Figure 2. *Lamp Configuration and Photograph of the Atlantic Megatron M250 System*

RESULTS AND DISCUSSION

Testing was conducted at the City of San Diego's Aqua 2000 Research Center located in Chula Vista, California, using treated Otay Lake filtered water as feedwater. Otay Lake water quality (see Table 1) is characterized by relatively high hardness and pH values, which can contribute to scaling/fouling of the lamp sleeves, and has elevated levels of organic material, which can result in low transmittance.

Both units were tested for approximately 45 days. A schematic of the testing treatment process is provided in Figure 3 (next page). Adequate mixing was achieved by mounting the units with at least five pipe diameters of straight pipe length before the unit and at least 3 pipe diameters after.

One virus seeding experiment using MS2 bacteriophage at a single flow rate was conducted in triplicate for each unit. A flow rate of 695 gpm and a UV lamp power setting of 81% was used for the Trojan UVSwift Model 4L12 unit. A flow rate of 350 gpm and a 100% lamp power setting was used for the Atlantic Megatron M250 unit. Any residual chlorine disinfectant was quenched with sodium metabisulfite prior to passage through the UV units. A set of positive control samples and concurrent collimated beam testing was also performed.

The results of the challenge studies for the two UV systems are presented in Figure 4 and Figure 5. The microbial inactivation observed during the challenge tests ranged from 2.1 to 3.0 logs for the Trojan UVSwift Model 4L12 and 1.7 to 2.1 logs for the Atlantic Megatron M250 unit. No inactivation was observed during the positive control tests with the lamps off.

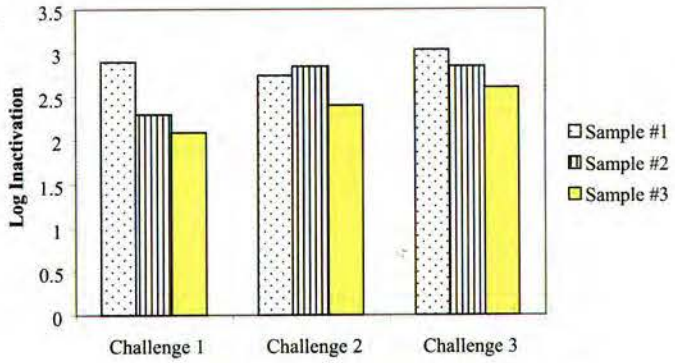

Figure 4. *Virus Seeding Results for Trojan UVSwift Model 4L12 (695 gpm).*

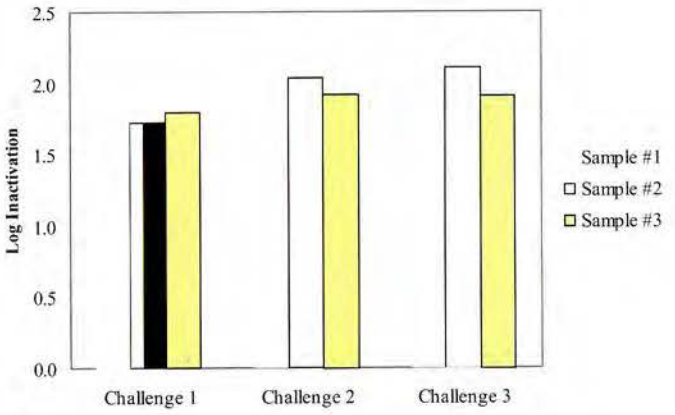

Figure 5. *Virus Seeding Results for Atlantic Megatron M250 (350 gpm).*

The Trojan Technologies UVSwift Model 4L12 power usage was 0.32 kwh/1000 gal at a flow rate of 400 gpm and a power setting of 81% for the. Power usage for the Atlantic Megatron M250 unit was 0.053 kwh/1000 gal at a flow rate of 350 gpm and 100% lamp power. Sensor calibration data for both units ranged from approximately 2% to 11% over the testing period.

Table 1. Otay Lake Feed Water Quality Characteristics

Parameter	Unit	Trojan Range	Atlantic Range
Alkalinity	mg/L as $CaCO_3$	127 – 168	111 - 137
Total Hardness	g/L as $CaCO_3$	196 – 227	212 - 259
Iron	µg/L	50 – 85	50 - 57
Manganese	g/L	0.91 – 9.3	0.5 – 1.8
Nitrate	mg/L	0.2 – 0.57	0.4 – 0.9
TOC	mg/L	2.96 – 5.11	2.3 – 4.6
Color	Pt CU	2 – 5	1– 3
UV254	1/cm	0.034 – 0.083	0.042 – 0.068
pH	std. Unit	7.3 – 8.9	7.5 – 8.6
Desktop Turbidity	NTU	0.10 – 0.20	0.10 – 0.10
Temperature	C	20.3 – 24.7	17.3 – 20.5
Free Chlorine	mg/L	0.04 – 1.4	0.07 – 3.20
Total Chlorine	mg/L	1.5 – 3.0	1.56 – 3.34

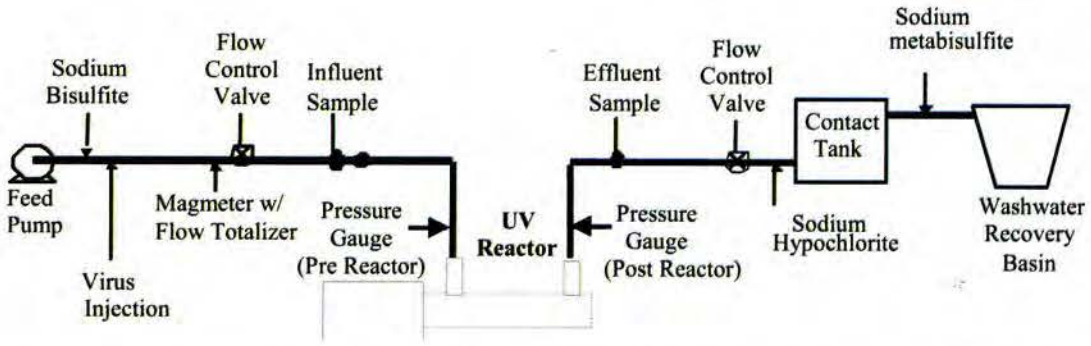

Figure 3. *Treatment Process Schematic (Shown for the Atlantic Megatron M250 identical for the Trojan UVSwift Model 4L12).*