THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**POINT-OF-USE DRINKING WATER TREATMENT SYSTEM**
APPLICATION:	**REMOVAL OF MICROBIAL CONTAMINANTS IN DRINKING WATER**
PRODUCT NAME:	**WATTS PREMIER WP-4V**
VENDOR:	**WATTS PREMIER**
ADDRESS:	**1725 WEST WILLIAMS DR. SUITE C-20 PHOENIX, AZ 85027**
PHONE:	**800-752-5582**
INTERNET	**http://www.wattspremier.com**

NSF International (NSF) manages the Drinking Water Systems (DWS) Center under the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program. The DWS Center recently evaluated the performance of the Watts Premier WP-4V point-of-use (POU) reverse osmosis (RO) drinking water treatment system. NSF performed all of the testing activities and also authored the verification report and this verification statement. The verification report contains a comprehensive description of the test.

EPA created the ETV Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

ABSTRACT

The Watts Premier WP-4V four-stage POU RO system was tested for removal of bacteria and viruses at NSF's Drinking Water Treatment Systems Laboratory. Five systems were challenged with the bacteriophage viruses fr and MS2, and the bacteria *Brevundimonas diminuta*. The virus challenges were conducted at three different pH settings (6, 7.5, and 9) to assess whether pH influences the performance of the RO membrane. The bacteria challenges were conducted only at pH 7.5.

The challenge concentrations ranged from 3.8 to 5.0 logs for the viruses, and 6.4 to 7.2 logs for the bacteria. The log reductions ranged from 1.3 to 6.4 $\log_{10}$ for *B. diminuta*, with an average of 2.1 $\log_{10}$. The virus log reductions ranged from 1.4 to 3.6 $\log_{10}$ for fr, and 1.2 to 3.7 $\log_{10}$ for MS2. The average virus $\log_{10}$ reductions were 2.5 and 2.7, respectively. The virus challenge data does not indicate that the pH of the challenge water influenced removal by the RO membrane. See Table VS-2 below for the complete log reduction data.

TECHNOLOGY DESCRIPTION

The following technology description was provided by the manufacturer and has not been verified.

The WP-4V is a four-stage POU drinking water treatment system using sediment filtration, activated carbon filtration, and reverse osmosis. Treated water is stored in a three-gallon storage tank. The WP-4V is certified by NSF to NSF/ANSI Standard 58 – *Reverse Osmosis Drinking Water Treatment Systems*. It has a certified production rate of 9.06 gallons per day.

Incoming water first passes through a sediment filter to remove particulate matter, such as rust and silt, and then through a carbon filter to remove chlorine or other contaminants. The third stage of treatment is the reverse osmosis membrane, which removes a wide variety of inorganic and larger molecular weight organic contaminants, and also protozoan cysts such as Cryptosporidium and Giardia. The permeate water is sent to a 3-gallon maximum capacity storage tank. Upon leaving the storage tank, the water passes through a second carbon filter to remove organic chemicals and other taste and odor causing substances before dispensing through the faucet. The pre-membrane carbon and sediment filters were not tested, because they are only designed to remove chlorine and particulate matter to protect the RO membrane.

VERIFICATION TESTING DESCRIPTION

Test Site

The testing site was the Drinking Water Treatment Systems Laboratory at NSF in Ann Arbor, Michigan. A description of the test apparatus can be found in the test/QA plan and verification report. The testing was conducted in June and July of 2005.

Methods and Procedures

The testing methods and procedures are detailed in the Test/QA Plan for Verification Testing of the Watts Premier WP-4V Point-of-Use Drinking Water Treatment System for Removal of Microbial Contamination Agents. Five WP-4V systems were tested for bacteria and virus removal performance using the bacteriophage viruses fr and MS2, and the bacteria Brevundimonas diminuta. The challenge organisms were chosen because they are smaller than most other viruses and bacteria, and so provide a conservative estimate of performance. NSF also used a genetically engineered strain of B. diminuta. The NSF Microbiology Laboratory inserted into a culture of B. diminuta strain 19146 a gene conferring resistance to the antibiotic kanamycin. This allowed the Microbiology Laboratory to use a growth media

amended with 50 µg/mL of kanamycin to prohibit heterotrophic plate count (HPC) bacteria in the treated water samples from growing along with the kanamycin resistant B. diminuta.

Five systems were evaluated. The systems were installed on a test rig and conditioned according to the vendor's instructions (fill the storage tanks and dispensing the contents to a drain three times), and then were conditioned for another five days. Prior to testing, the systems were evaluated for reduction of total dissolved solids (TDS) to ensure that the systems undergoing testing were representative of the expected performance of the system.

The test water for the bacteria challenges was set to pH 7.5 ± 0.5, while the virus challenges were conducted at pH 6.0 ± 0.5, 7.5 ± 0.5, and 9.0 ± 0.5. The challenge schedule is shown in Table VS-1. The virus challenges were conducted at different pH settings to evaluate whether the surface charges of the viruses influenced their removal through electrostatic forces versus mechanical filtration. Viruses have different surface charges, or different strengths of negative or positive charge, depending on their isoelectric point and the pH of the water. The isoelectric point is the pH at which the virus surface is neutrally charged. MS2's isoelectric point is pH 3.9, and fr's is pH 8.9. In solutions above the isoelectric point, the virus is negatively charged. Below the isoelectric point, the virus is positively charged.

Table VS-1. Challenge Schedule

Day	Surrogate Challenge	pH
1	*B. diminuta*	7.5 ± 0.5
2	fr and MS2	6.0 ± 0.5
3	fr and MS2	7.5 ± 0.5
4	Kanamycin Resistant *B. diminuta*	7.5 ± 0.5
5	fr and MS2	9.0 ± 0.5

For each challenge, the systems were operated for one tank-fill period (approximately four to five hours). The end of this period was evident through engagement of each system's automatic shutoff mechanism, which causes the flow of reject water to cease. Influent water samples were collected at the beginning and end of each challenge period. After each system ceased operation, the contents of the product water storage tanks were emptied into sterile containers, and samples were collected for microbiological analysis. All samples were enumerated in triplicate. Following each challenge period, the systems were flushed by operating them for one tank-fill period using water without challenge organisms.

VERIFICATION OF PERFORMANCE

As discussed above, the systems were first subjected to a TDS reduction test to verify that the RO membranes would perform as expected. The observed TDS reduction ranged from 89% to 96%. The certified TDS reduction for the WP-4V is 97%.

The bacteria and virus $\log_{10}$ reduction data is presented in Table VS-2. The $\log_{10}$ reduction of *B. diminuta* ("normal" and kanamycin resistant *B. diminuta* combined) ranged from 1.3 to 6.4, with an average $\log_{10}$ reduction of 1.9. The challenge organisms were detected in the effluent samples for all test units but Unit 2 for the "normal" *B. diminuta* challenge. Since the Unit 2 effluent count for kanamycin resistant *B. diminuta* was 4.3 $\log_{10}$, and all other effluent samples had bacteria counts greater than 4 $\log_{10}$ (data not shown), it is possible that there was a sampling or analytical error associated with the Unit 2 "normal" *B. diminuta* sample. Therefore, that sample was not included in the mean $\log_{10}$ reduction calculation for the bacteria.

The virus challenge data showed similar performance. The log_{10} reduction of the fr virus ranged from 1.4 to 3.6, with an overall mean of 2.5. The log_{10} reduction of MS2 ranged from 1.2 to 3.7, with an overall mean of 2.6. A visual comparison of the log_{10} reductions versus the challenge water pH shows the mean log_{10} reductions decreasing with increasing pH. However, an examination of the 95% confidence intervals around the means (see verification report for data) shows that the decreases are not statistically significant.

The minimum observed log reductions equal removal of 95% of *B. diminuta*, and 94% of the viruses.

Table VS-2. Bacteria and Virus Log Reduction Data

Target pH	Initial Measured pH	Final Measured pH	Challenge Organisms	Log_{10} Influent Challenge	Geometric Mean Log_{10} Reduction					
					Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Mean
7.5 ± 0.5	7.6	7.8	*B. diminuta*	6.4	1.8	6.4*	1.3	1.5	1.6	1.5
7.5 ± 0.5	7.5	7.8	Kanamycin Resistant *B. diminuta*	7.2	1.4	2.9	2.6	2.6	3.1	2.4
6.0 ± 0.5	6.1	6.5	fr	3.9	1.8	3.1	3.6	3.4	3.0	2.9
			MS2	3.8	2.3	3.4	3.7	3.6	2.9	3.1
7.5 ± 0.5	7.5	7.7	fr	4.5	1.9	2.4	2.3	3.1	2.8	2.5
			MS2	4.2	1.7	2.4	2.4	3.4	3.2	2.5
9.0 ± 0.5	8.9	9.0	fr	5.0	1.4	2.3	2.1	2.3	2.6	2.1
			MS2	4.6	1.2	2.4	2.0	2.3	3.0	2.1
						Overall Means:		*B. diminuta*		1.9
									fr	2.5
									MS2	2.6

*Number not included in mean log reduction calculation.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

NSF provided technical and quality assurance oversight of the verification testing as described in the verification report, including a review of nearly 100% of the data. NSF personnel also conducted a technical systems audit during testing to ensure the testing was in compliance with the test plan. A complete description of the QA/QC procedures is provided in the verification report.

Original signed by Sally Gutierrez 08/11/06

Sally Gutierrez Date
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National Risk Management Research Laboratory
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Original signed by Robert Ferguson 08/23/06

Robert Ferguson Date
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Availability of Supporting Documents

Copies of the test protocol, the verification statement, and the verification report (NSF report # NSF 06/12b/EPADWCTR) are available from the following sources:

(NOTE: Appendices are not included in the verification report. Appendices are available from NSF upon request.)

1. ETV Drinking Water Systems Center Manager (order hard copy)
   NSF International
   P.O. Box 130140
   Ann Arbor, Michigan 48113-0140

2. Electronic PDF copy
   NSF web site: http://www.nsf.org/etv
   EPA web site: http://www.epa.gov/etv