THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**POINT-OF-USE REVERSE OSMOSIS DRINKING WATER TREATMENT SYSTEM**	
APPLICATION:	**REMOVAL OF MICROBIAL CONTAMINATION AGENTS IN DRINKING WATER**	
PRODUCT NAME:	**WATTS PREMIER ULTRA 5**	
COMPANY:	**WATTS PREMIER, INC.**	
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	PHOENIX, AZ 85027	FAX: **623-931-0191**

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, Inc. Ultra 5 point-of-use (POU) reverse osmosis 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 Ultra 5 was tested for removal of bacteria and viruses at NSF's Drinking Water Treatment Systems Laboratory. Watts Premier submitted ten units, which were split into two groups of five. One group received 25 days of conditioning prior to challenge testing, while the second group was tested immediately. Due to an incorrectly installed shut-off valve on one of the unconditioned units, only four in this group were tested. Both groups were challenged identically. The challenge organisms were the viruses fr, MS2, and Phi X 174, and the bacteria *Brevundimonas diminuta* and *Hydrogenophaga pseudoflava*. The test units were challenged at two different inlet pressures – 40 and 80 pounds per square inch, gauge (psig). The virus challenges were conducted at three different pH settings (6, 7.5, and 9) with the intent to assess whether pH influenced the performance of the test units. The bacteria challenges were only conducted at pH 7.5.

In most cases, the test units significantly reduced the challenge organisms, with reductions greater than 4.0 $\log_{10}$. The $\log_{10}$ reduction data is shown in Tables 3 through 6. Overall, the performance of the conditioned units was better than that of the unconditioned units. Also, the unconditioned units exhibited wider unit-to-unit performance variation than the conditioned units. The $\log_{10}$ reduction data does not conclusively show that inlet pressure or pH influenced test unit performance.

TECHNOLOGY DESCRIPTION

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

The Watts Premier Ultra 5 is a five-stage POU drinking water treatment system. It employs carbon filtration and reverse osmosis processes to remove contaminants from drinking water. It is sold with a faucet that is installed at the kitchen sink, and the system itself is installed either under the kitchen sink or in another location.

During operation, inlet water first passes through a sediment filter, and then through two carbon block filters. The fourth stage is passage through the reverse osmosis membrane. The portion of the inlet water that passes through the membrane travels to the product water storage tank. When the user opens the faucet, the water leaves the storage tank and travels through a final carbon filter before exiting the faucet. The system is designed to produce approximately 12 gallons of reject water for each gallon of treated water produced.

The test units were evaluated without the carbon filters or sediment filter in place to eliminate the possibility that these filters could temporarily trap a portion of the challenge organisms, causing a positive bias of system performance during testing.

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/quality assurance (QA) plan and verification report. The testing was conducted in September and October of 2003.

Methods and Procedures

The testing methods and procedures are detailed in the *Test/QA Plan for Verification Testing of the Watts Premier Ultra 5 Point-of-Use Reverse Osmosis Drinking Water Treatment System for Removal of Microbial Contamination Agents.* Nine test units were verified for bacteria and virus removal

performance using the bacteriophage viruses fr, MS2, and Phi X 174, and the bacteria *B. diminuta* and *H. pseudoflava*. The challenge organisms were chosen because they are smaller than most other viruses and bacteria, and so provide a conservative estimate of performance.

Watts Premier submitted ten units, which were split into two groups of five according to the performance of each membrane in the manufacturer's quality control testing. One group was conditioned for 25 days prior to challenge testing by operating the units daily using the test water without challenge organisms. The second group was challenged without receiving the 25-day conditioning period. Due to an incorrectly installed shut-off valve on one of the unconditioned units, only four in this group were tested.

The test units were challenged at both 40 and 80 psig inlet pressure. The test water for the bacteria challenges was set to pH 7.5 ± 0.5. The test water for the virus challenges was set at pH 6.0 ± 0.5, 7.5 ± 0.5, and 9.0 ± 0.5. However, it had a low buffering capacity, so the lab technicians had difficulty maintaining the pH within the 9.0 ± 0.5 range. As a result, the pH for the conditioned units pH 9, 80 psig challenge was only 7.9. The test water pH values for all other challenges were within the allowable ranges. These challenge conditions were intended to evaluate whether inlet pressure or pH influences bacteria and virus removal. Table 1 shows the challenge schedule for the conditioned units, while Table 2 shows the schedule for the unconditioned units. The challenge levels ranged from 3.4 to 6.4 $\log_{10}$ for the viruses, and 6.7 to 8.4 $\log_{10}$ for the bacteria.

Table 1. Conditioned Units Challenge Schedule

Day	Challenge Organism(s)	pH (± 0.5 units)	Inlet Pressure (± 3 psig)
1	All Viruses	6.0	40
2	All Viruses	6.0	80
3	All Viruses	7.5	40
4	All Viruses	7.5	80
5	All Viruses	9.0	40
6	All Viruses	9.0	80
7	*H. pseudoflava*	7.5	80
8	*H. pseudoflava*	7.5	40
9	*B. diminuta*	7.5	40
10	*B. diminuta*	7.5	80

Table 2. Unconditioned Units Challenge Schedule

Day	Challenge Organism(s)	pH (± 0.5 units)	Inlet Pressure (± 3 psig)
1	*H. pseudoflava*	7.5	80
2	*H. pseudoflava*	7.5	40
3	*B. diminuta*	7.5	40
4	*B. diminuta*	7.5	80
5	All Viruses	6.0	40
6	All Viruses	6.0	80
7	All Viruses	7.5	40
8	All Viruses	7.5	80
9	All Viruses	9.0	40
10	All Viruses	9.0	80

On each challenge day, the test units were operated for one tank-fill period (approximately six to eight hours). The end of this period was evident through engagement of the system's automatic shutoff mechanism, which causes the flow of reject water to cease. At 40 psig, not all of the shut-off mechanisms engaged after 8 hours of operation due to the low pressure. The storage tanks were nearly full in these instances, so operation of the units was stopped manually.

Influent water samples were collected at the beginning and end of the challenge period. After each test unit ceased operation, the entire contents of the product water storage tank were emptied into a sterile container, and a subsample was collected for microbiological analysis. All samples were enumerated in triplicate. Following each challenge period, the test units were flushed by operating them for one tank-fill period using the test water without challenge organisms.

VERIFICATION OF PERFORMANCE

The bacteria reduction data are presented in Tables 3 and 4, and the virus reduction data in Tables 5 and 6. An examination of the bacteria reduction data shows that for the five conditioned test units, in only one case (unit 4 for *B. diminuta* at pH 7.5, 40 psig) was one of the bacteria species detected in the effluent samples. In contrast, for the unconditioned units, there were 13 cases out of 16 where the challenge bacteria were detected in the effluents.

An evaluation of the virus reduction data shows that overall, the conditioned units performed better than the unconditioned units. The mean $\log_{10}$ reductions and mean $\log_{10}$ effluent counts are shown in the bottom right corner of Tables 5 and 6. A comparison of the mean $\log_{10}$ effluent counts for the unconditioned versus conditioned units shows that the conditioned units performed approximately 0.3 to 1.7 $\log_{10}$ better than the unconditioned units.

The unit-to-unit performance variation for the unconditioned units was wider than for the conditioned units, and the performance of each unconditioned unit also varied more from day-to-day. Also, the unconditioned units had many cases where bacteria reduction performance was less than virus reduction performance. The reasons for these observations are not known, but the data suggest that conditioning the systems improves and/or stabilizes their performance. The data does not conclusively show whether inlet pressure or pH influenced test unit performance.

Table 3. Bacteria Log Reduction Data for Unconditioned Units

pH	Pressure (psig)	Challenge Organisms	$\log_{10}$ Influent Challenge	Geometric Mean $\log_{10}$ Reduction Unit 1	Unit 2	Unit 3	Unit 4
7.5	40	*H. pseudoflava*	6.9	4.4	4.9	2.2	1.6
		B. diminuta	8.2	8.2	3.0	2.0	8.2
7.5	80	*H. pseudoflava*	6.9	4.6	6.6	1.9	3.0
		B. diminuta	8.1	3.5	2.2	3.3	8.1

Table 4. Bacteria Log Reduction Data for Conditioned Units

pH	Pressure (psig)	Challenge Organisms	$\log_{10}$ Influent Challenge	Geometric Mean $\log_{10}$ Reduction Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
7.5	40	*H. pseudoflava*	6.7	6.7	6.7	6.7	6.7	6.7
		B. diminuta	8.3	8.3	8.3	8.3	7.2	8.3
7.5	80	*H. pseudoflava*	6.7	6.7	6.7	6.7	6.7	6.7
		B. diminuta	8.4	8.4	8.4	8.4	8.4	8.4

Table 5. Virus Log Reduction Data for Unconditioned Units

Challenge Conditions				Log_{10}	Geometric Mean Log_{10} Reduction					Log_{10}
Target pH	Actual pH	Pressure (psig)	Challenge Organisms	Influent Challenge	Unit 1	Unit 2	Unit 3	Unit 4	Mean[1]	Mean Effluent Count
6.0 ± 0.5	6.5	40	fr	6.3	4.8	3.1	2.9	4.6	3.8	2.5
			MS2	6.1	5.6[2]	3.0	2.8	4.7	4.0	2.1
			Phi X 174	5.0	5.0	2.4	2.3	5.0[2]	3.7	1.3
6.0 ± 0.5	6.2	80	fr	5.9	4.5	3.2	3.3	5.9	4.2	1.7
			MS2	5.8	4.5	3.0	3.3	5.8	4.2	1.6
			Phi X 174	4.9	4.6[2]	2.8	2.4	4.9	3.7	1.2
7.5 ± 0.5	7.6	40	fr	5.9	4.0	2.9	4.9	4.4	4.1	1.8
			MS2	5.6	3.8	2.7	5.0	4.3	4.0	1.6
			Phi X 174	5.7	3.7	2.3	5.7[2]	4.3	4.0	1.7
7.5 ± 0.5	7.7	80	fr	5.8	4.6	2.5	4.3	5.5	4.2	1.6
			MS2	5.7	4.4	2.6	4.3	5.4[2]	4.2	1.5
			Phi X 174	5.9	4.3	2.6	3.7	5.1	3.9	2.0
9.0 ± 0.5	8.7	40	fr	5.8	4.4	2.9	4.2	4.8	4.1	1.7
			MS2	5.6	4.1	2.7	4.1	4.8	3.9	1.7
			Phi X 174	5.7	3.8	2.6	3.3	4.1	3.5	2.2
9.0 ± 0.5	9.0	80	fr	6.0	4.6	3.5	3.7	5.1	4.2	1.8
			MS2	5.7	4.7	3.4	3.8	5.1	4.3	1.4
			Phi X 174	5.6	4.1	3.5	3.5	4.5	3.9	1.7
				fr mean[3]	4.5	3.0	3.9	5.1	4.1	1.9
				MS2 mean[3]	4.5	2.9	3.9	5.0	4.1	1.7
				Phi X 174 mean[3]	4.3	2.7	3.5	4.7	3.6	1.7

[1] The arithmetic mean of all test units for each challenge.
[2] Triplicate count had two "non-detect" agar plates.
3 The arithmetic mean for all challenges against each test unit.

Table 6. Virus Log Reduction Data for Conditioned Units

Challenge Conditions				Log_{10}	Geometric Mean Log_{10} Reduction						Log_{10} Mean
Target pH	Actual pH	Pressure (psig)	Challenge Organisms	Influent Challenge	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Mean[1]	Effluent Count
6.0 ± 0.5	6.5	40	fr	5.1	3.6	4.1	4.0	4.8	4.0	4.1	1.0
			MS2	4.8	3.2	3.7	3.8	4.1	3.2	3.6	1.2
			Phi X 174	3.4	3.4	3.4	3.4	3.4	3.4	3.4	0.0
6.0 ± 0.5	6.4	80	fr	6.1	4.6	4.2	4.3	4.7	4.6	4.5	1.6
			MS2	6.0	4.6	4.2	4.2	4.8	3.7	4.3	1.7
			Phi X 174	3.8	3.8	3.8	3.8	3.8	3.8	3.8	0.0
7.5 ± 0.5	7.5	40	fr	6.4	4.2	4.8	4.7	4.8	4.2	4.5	1.9
			MS2	6.2	4.2	4.5	4.8	4.7	4.3	4.5	1.7
			Phi X 174	4.0	3.7	4.0[2]	4.0[2]	4.0	3.7	3.9	0.1
7.5 ± 0.5	7.3	80	fr	6.3	4.8	5.6	5.6	5.3	4.8	5.2	1.1
			MS2	6.1	5.2	5.5	5.6	4.9	5.0	5.2	0.9
			Phi X 174	4.1	4.1	4.1[2]	4.1	4.1	4.1[2]	4.1	0.1
9.0 ± 0.5	8.9	40	fr	6.2	4.4	4.2	4.3	4.3	4.3	4.3	1.9
			MS2	5.8	4.2	4.0	4.2	4.1	4.2	4.1	1.7
			Phi X 174	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.0
9.0 ± 0.5	7.9[3]	80	fr	6.0	4.4	4.9	4.7	4.7	4.6	4.7	1.3
			MS2	5.9	4.3	5.9	4.8	4.9	4.6	4.9	1.0
			Phi X 174	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0
				fr mean[4]	4.3	4.6	4.6	4.8	4.4	4.6	1.5
				MS2 mean[4]	4.3	4.6	4.6	4.6	4.2	4.4	1.4
				Phi X 174 mean[4]	3.9	3.9	3.9	3.9	3.9	3.9	0.0

[1] The arithmetic mean of all test units for each challenge.
[2] Triplicate count had two "non-detect" agar plates.
[3] See section 5.8.3 of verification report for discussion of pH variance.
[4] The arithmetic mean for all challenges against each test unit.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

NSF personnel conducted a technical systems audit during testing to ensure that the testing was in compliance with the test plan. NSF also conducted a data quality audit of 100% of the data. Please see the verification report referenced below for more QA/QC information.

Original signed by	*Original signed by*
E. Timothy Oppelt *07/12/04*	*Gordon Bellen* *07/16/04*
E. Timothy Oppelt Date	Gordon Bellen Date
Director	Vice President
National Homeland Security Research Center	Research
United States Environmental Protection Agency	NSF International

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Availability of Supporting Documents

Copies of the test protocol, the Verification Statement, and the Verification Report (NSF Report # NSF 04/12/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. NSF web site: http://www.nsf.org/etv/dws/dws_reports.html and from http://www.nsf.org/etv/dws/dws_project_documents.html (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)