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 CHEMICAL CONTAMINANTS IN DRINKING WATER**	
PRODUCT NAME:	**PALL/KINETICO PUREFECTA™**	
COMPANY:	**KINETICO INCORPORATED**	
ADDRESS:	**10845 KINSMAN ROAD**	PHONE: **800-944-9283**
	NEWBURY, OH 44065	FAX: **440-564-9541**
EMAIL:	**CUSTSERV@KINETICO.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 Pall/Kinetico Purefecta™ point-of-use (POU) 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 Pall/Kinetico Purefecta™ POU drinking water treatment system was tested for removal of aldicarb, benzene, cadmium, carbofuran, cesium, chloroform, dichlorvos, dicrotophos, fenamiphos, mercury, mevinphos, oxamyl, strontium, and strychnine. The Purefecta™ employs several components: a reverse osmosis (RO) membrane, carbon filters, and a bacteria/virus removal filter to treat drinking water. Treated water is stored in a three-gallon storage tank. The system was first tested with only the RO membrane component in place. The target challenge concentration of each chemical for each RO membrane test was 1 mg/L. Following the RO membrane challenges, the post-membrane carbon filter component was challenged alone with each chemical that the RO membrane did not remove to below 10 µg/L, except for cesium, which is not well removed by carbon. The target feed concentration of each chemical to a carbon filter component was the maximum effluent level measured during the RO membrane tests.

A total of 20 RO membrane components were tested, divided into ten pairs. Each pair of membranes was tested with only one of the ten organic chemicals because of concern that a chemical could compromise the integrity of the membrane material or membrane seals. One pair of RO membrane components was also challenged with the inorganic chemicals. Each RO membrane chemical challenge was conducted over a one-day period. Influent and effluent samples were collected during the operation period, and also the next morning. Post-membrane carbon filter challenges were conducted over a 15-hour duration. Two filters were tested for each chemical challenge, and each pair was only used for one challenge. Influent and effluent samples were collected at the beginning, middle, and end of the challenge period.

The Purefecta™ system as a whole, considering both the RO membrane challenge and post-membrane carbon filter challenge results combined, reduced all of the challenge chemicals by 99% or more, except for cesium.

TECHNOLOGY DESCRIPTION

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

The Purefecta™ is a five-stage POU drinking water treatment system. It employs activated carbon filters and an RO membrane to remove chemical contaminants from drinking water, and a mechanical filtration "biofilter" to remove microorganisms. The system includes a three-gallon maximum capacity pressurized bladder tank for storing the treated water, and a faucet to mount on the kitchen sink. The biofilter is manufactured by the Pall Corporation and supplied to Kinetico, who manufactures the system.

The influent water first passes through a pre-membrane sediment or carbon filter, and then through the RO membrane. The permeate water travels through the first stage of the Pall biofilter for virus removal, and then into the storage tank. When the flow of water into the system is started, treated water will be continually produced until the storage tank is nearly full. At that time, the water pressure in the tank activates an automatic shut-off device, stopping the flow of water through the system. After a portion of the water is dispensed from the storage tank, the shut-off device deactivates, allowing water to again flow into the system until the storage tank is nearly full. When the user opens the faucet, the partially treated water exits the storage tank, passes through the post-membrane carbon filter, and finally through the bacteria removal portion of the Pall biofilter. The Purefecta™ is designed to produce approximately four gallons of reject water for every gallon of treated water.

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 August through November of 2004.

Methods and Procedures

Verification testing followed the procedures and methods detailed in the *Test/QA Plan for Verification Testing of the Pall/Kinetico Purefecta™ Point-of-Use Drinking Water Treatment System for Removal of Chemical Contamination Agents.* Because any contamination event would likely be short-lived, the challenge period for each chemical lasted only one day. Long-term performance over the life of the membrane was not investigated.

The system was first tested with only the RO membrane component in place. The complete Purefecta™ system, including the storage tank, was used for these tests, but empty cartridges were used in place of the carbon and bacteria/virus filters. A total of 20 RO membranes were challenged with the chemicals in Table 1. The target challenge concentration for each chemical was 1 mg/L. The 20 RO membrane components were divided into ten pairs. Each pair was tested with only one of the ten organic chemicals because of concern that a chemical, especially benzene or chloroform, could compromise the integrity of the membrane material or membrane seals. One pair of the RO membrane components was also challenged with the inorganic chemicals. The inorganic chemical challenges were conducted prior to the organic challenges to eliminate the possibility of damage to the membranes that could bias the inorganic chemical challenge results. Reduction of total dissolved solids (TDS) was also measured to evaluate whether any organic chemicals damaged the membrane material or membrane seals during the challenges.

Table 1. Challenge Chemicals

Organic Chemicals	Inorganic Chemicals
Aldicarb	Cadmium Chloride
Benzene	Cesium Chloride (nonradioactive isotope)
Carbofuran	Mercuric Chloride
Chloroform	Strontium Chloride (nonradioactive isotope)
Dicrotophos	
Dichlorvos	
Fenamiphos	
Mevinphos	
Oxamyl	
Strychnine	

Prior to chemical challenge testing, the RO membrane components were service-conditioned for seven days by feeding the systems test water without any chemical spikes. After completion of the conditioning period, the membranes were subjected to a TDS reduction test using sodium chloride to verify that they were operating properly. Each RO membrane chemical challenge was conducted over a one-day period.

The systems were operated for six tank-fill periods, and then were allowed to rest overnight. Influent and effluent samples were collected at start-up, after the 3rd tank fill, after the 5th tank fill, and the next morning after the membranes rested under pressure overnight.

Following the RO membrane challenges, post-membrane carbon filters were challenged with the chemicals that the RO membrane did not remove to below 10 µg/L, except for cesium, which is not well removed by carbon. The carbon filters were attached to a separate manifold that was of the same design as the manifold in the full system. The pre-membrane carbon filter was not tested because it is only designed to remove chlorine to protect the RO membrane. Two carbon filter components were tested for each chemical challenge, and each filter was only used for one challenge. The target challenge concentrations were the maximum effluent levels measured during the RO membrane tests.

Prior to testing, each carbon filter was service-conditioned by feeding water containing chloroform to simulate the potential chemical loading on the carbon halfway through the filter's effective lifespan. The target chloroform concentration was 300 ± 90 µg/L, which is the influent challenge concentration for the VOC reduction test in NSF/ANSI Standard 53 (chloroform is the surrogate challenge chemical for the test). The filters were operated at a flow rate of 0.5 gallons per minute (gpm) for 250 gallons (Kinetico's design capacity for the filter is 500 gallons).

The post-membrane carbon filter challenges were 15 hours in duration. Influent and effluent samples were collected at the beginning, middle, and end of the challenge period. The carbon filters were operated on an "on/off" operation cycle where the "on" portion was the time required to empty the system storage tank when full, and the "off" portion was the time required to fill the storage tank.

VERIFICATION OF PERFORMANCE

The results of the RO membrane challenges are presented in Table 2. The RO membrane treatment process removed 96% or more of all challenge chemicals except mercury and chloroform. The TDS reduction by each membrane component for all challenge tests was 94% or higher, and the TDS levels in the treated water samples did not increase through any of the challenge periods. This indicates that none of the chemicals compromised the performance of the membrane components to a degree that could be detected.

Table 2. RO Membrane Challenge Data

Chemical	Mean Influent (µg/L)	Mean Effluent (µg/L)	Percent Reduction (%)
Cadmium	1000	1.9	>99
Cesium	1000	40	96
Mercury	1100	680	38
Strontium	850	2	99
Aldicarb	950	7	>99
Benzene	1100	48	96
Carbofuran	950	6	>99
Chloroform	1100	170	85
Dichlorvos	1100	23	98
Dicrotophos	790	ND (10)	99
Fenamiphos	740	2	>99
Mevinphos	1400	19	99
Oxamyl	980	5	>99
Strychnine	1100	18	98

The post-membrane carbon filter components were challenged with mercury, benzene, chloroform, dichlorvos, mevinphos, and strychnine, based on the criteria that the RO membrane challenge effluents were above 10 µg/L. The target challenge levels were the maximum effluent levels measured during the RO membrane challenges. The carbon filters were operated at 0.8 gpm on an operation cycle where the "on" portion was four minutes and thirty seconds, and the "off" portion was one hour and ten minutes.

The carbon challenge results are shown below in Table 3. The carbon filters reduced all substances to non-detectible levels, except for mercury. However, the mean effluent value for mercury was only 2.7 µg/L, which still gives a percent reduction greater than 99%. Note that the percent reduction of strychnine was limited by the detection limit for the chemical.

The RO membrane and carbon challenge data combined shows that the two treatment technologies working in concert within the Purefecta™ system removed 99% or more of all of the challenge chemicals, except for cesium.

Complete descriptions of the verification testing results are included in the verification report.

Table 3. Post-Membrane Carbon Filter Challenge Data

Chemical	Mean Influent (µg/L)	Mean Effluent (µg/L)	Percent Reduction (%)
Mercury	960	2.7	> 99
Benzene	83	ND (0.5)	> 99
Chloroform	320	ND (0.5)	> 99
Dichlorvos	29	ND (0.2)	> 99
Mevinphos	20	ND (0.2)	99
Strychnine	31	ND (5)	84

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

NSF ETV and QA staff monitored the testing activities 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 Andrew Avel, 9/26/05

Andrew P. Avel Date
Acting Director
National Homeland Security Research Center
United States Environmental Protection Agency

Original signed by Robert Ferguson, 10/5/05

Robert Ferguson Date
Vice President
Water Systems
NSF International

NOTICE: Verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. EPA and NSF make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end-user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of corporate names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products. This report is not an NSF Certification of the specific product mentioned herein.

Availability of Supporting Documents

Copies of the test protocol, the verification statement, and the verification report (NSF report # NSF 04/13b/EPADWCTR) are available from the following sources:
(NOTE: Not all of the appendices are included in the verification report. The 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)
   EPA web site: http://www.epa.gov/etv (electronic copy)