THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**BACKWASHABLE DEPTH FILTRATION USED IN DRINKING WATER TREATMENT SYSTEMS**	
APPLICATION:	**PHYSICAL REMOVAL OF *GIARDIA* CYSTS AND *CRYPTOSPORIDIUM* OOCYSTS IN DRINKING WATER**	
TECHNOLOGY NAME:	**SW224 BACKWASHABLE MACROLITE® PRESSURE FILTRATION SYSTEM**	
COMPANY:	**KINETICO INCORPORATED**	
ADDRESS:	**10845 KINSMAN ROAD** **NEWBURY, OHIO 44065**	PHONE: **(440) 564-9111** FAX: **(440) 564-9541**
WEB SITE:	**www.kinetico.com**	
EMAIL:	**glatimer@kinetico.com**	

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (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 substantially 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; stakeholders groups which consist 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.

NSF International (NSF) in cooperation with the EPA operates the Drinking Water Treatment Systems (DWTS) Pilot, one of 12 technology areas under ETV. The DWTS Pilot recently evaluated the performance of a backwashable depth filter system used in drinking water treatment system applications. This verification statement provides a summary of the test results for the Kinetico Incorporated SW224 Backwashable Macrolite® Pressure Filtration System. Cartwright, Olsen and Associates, an NSF-qualified field testing organization (FTO), performed the verification testing.

ABSTRACT

Verification testing of the Kinetico Incorporated SW224 Backwashable Macrolite® Pressure Filtration System was conducted for 32½ days between March 24 and May 1, 2000, and three protozoan challenges were performed between April 24 and 27, 2000. Between March 24 and May 1, 2000, raw water characteristics were: average pH 8.6, temperature 10.3°C, turbidity 0.77 Nephlometric Turbidity Units (NTU), and total alkalinity 53 mg/L. Average calculated flow rate over the test period was 27.98 gpm. The filter runs averaged 11.7 hours, with an average of 21,075 gallons per filter run. The average effluent turbidity was 0.23 NTU. During the protozoan challenges the raw water characteristics were: average pH 9.2, temperature 11.4°C, turbidity 0.6 NTU, and total alkalinity in the range of 50-52 mg/L. The average effluent turbidity was 0.2 NTU. The system demonstrated 1.6 to 3.7 $\log_{10}$ reductions of *Giardia lamblia* (*G. lamblia*) cysts and 0 to 0.8 $\log_{10}$ reductions of *Cryptosporidium parvum* (*C. parvum*) oocysts. These results were obtained at an average flow rate of 28.4 gpm. Analysis of filter effluent samples suggest *G. lamblia* cysts and *C. parvum* oocysts were released from the filter bed as a result of the stop/start sequence.

TECHNOLOGY DESCRIPTION

The Kinetico SW224 is designed expressly for small system applications. Media vessels (filters) measured 24" in diameter and 72" in height and are offered in fiberglass or steel construction. Fiberglass reinforced polyethylene media tanks, pressure rated to 100 psi, were used for this study. The liquid volume capacity of each media vessel is 119 gallons without media. Filter media bed depth was 36".

Two identical filters are used within the Kinetico SW224 Filter System. Filters are identified as "T1A" and "T2A" and operating alternately. The filter media is Macrolite®, a synthetic ceramic, filter media.

Macrolite® of the 70/80 mesh size has a bulk density of 0.96 grams/cubic centimeter (g/cc). The specific gravity (as measured by American Society for Testing and Materials (ASTM) D2840) is 2.23 g/cc. The collapse strength for the media of this size has not been measured, however, for a larger sphere (30/50 mesh) the collapse strength (as measured by ASTM D3102) is a nominal 7,000 psi for 10% and nominal 8,000 psi for 20% collapse.

The uniformity of the Macrolite® 70/80 mesh media was analyzed in accordance with AWWA Standard B100-96 by Bowser-Morner, Inc in December, 1997. The results of this analysis are summarized below:

Uniformity of the Macrolite® 70/80 Mesh Media (AWWA Standard B100-96)

Sieve Size, USA Std.	Nominal, mm	Effective, mm	Percent passing
#45	0.355	0.360	100.0
#50	0.300	0.307	99.9
#60	0.250	0.249	79.8
#70	0.212	0.212	28.9
#80	0.180	0.180	7.2
#100	0.150	0.150	0.4

Effective Size: 0.19 mm
Uniformity Coefficient: 1.2

In addition, a June 1998 Kinetico internal laboratory analysis of 70 mesh media (lot # 352) employing a mercury/penetrometer Micromeritics Autopore II 9220 instrument produced the following results:

Uniformity of the Macrolite® 70/80 Mesh Media (Micromeritics Autopore)

Total intrusion volume	0.2098 mL/g
Total pore area	0.18 sq-m/g
Median pore diameter by volume	53.7990 µm
Median pore diameter by area	52.5351 µm
Median pore diameter by 4V/A	46.5685 µm

The flow of water through the system is controlled with hydro pneumatically actuated valves mounted on face piping constructed of Schedule 80 PVC. Automatic valves are actuated via a programmable logic controller. The valves also have handles for manual activation.

Accessories and instrumentation included with the Kinetico SW224 System included flow rate and pressure sensors and monitors, on-line turbidimeters, pressure gauges, backwash pumps and an electrical enclosure containing a programmable logic controller and a touch screen monitor. The equipment also contained data transfer connections available for remote monitoring.

The filters are shipped skid mounted and absent of media. Filter media was loaded on site. The total weight of the system, without media, is approximately 1,700 pounds. Spatial size of the Kinetico SW224 Filter System was 4'1¼" W x 9'6½' L x 8'7¼" H.

VERIFICATION TESTING DESCRIPTION

Test Site

The host site for this demonstration was the University of Minnesota St. Anthony Falls Hydraulic Laboratory (SAFHL), which has direct access to untreated and treated Mississippi river water. SAFHL is located on the Mississippi River at Third Avenue S.E., Minneapolis, Minnesota 55414. Influent to the Kinetico SW224 system was a blend of river water and treated water from the Minneapolis Water Works.

Methods and Procedures

The verification test was divided into tasks that evaluated the system's treatment performance, specifically its ability to physically remove *G. lamblia* cysts and *C. parvum* oocysts from the feed water, and documented the system's operational parameters.

Water quality parameters that were monitored during the verification test included: pH, temperature, turbidity, particle counts, free chlorine residual, total alkalinity, total hardness, total organic carbon (TOC), ultraviolet absorbance (UVA) at 254 nanometer (nm), true color, iron, manganese, algae, total coliform, and *E. coli*. Laboratory analyses were performed in accordance with the procedures and protocols established in *Standard Methods for the Examination of Water and Wastewater,* 19th Edition *(SM*) or EPA-approved methods.

Three seeding challenges employing *G. lamblia* cysts and *C. parvum* oocysts occurred between April 24 and 27, 2000. The protozoan analyses (identification and enumeration) were conducted using EPA Method 1623. During seeding studies, sodium thiosulfate was injected into the blended feedwater stream in place of chlorine to reduce chlorine residuals within the filter influent water previous to the point of protozoan injection. A mixture of cysts and oocysts was added to the raw water through an injection probe at the intake of the static mixer. The analyses of the influent samples indicated that the mixture contained between 660,000 and 3,800,000 *G. lamblia* cysts per liter, and between 2,800,000 and 17,000,000 *C. parvum* oocysts per liter during the three seeding challenges. During the seedings, 10 liters were collected from a side stream at a rate of 170 milliliters per minute over a one-hour period (equivalent to 20 bed volumes) and filtered through a Gelman capsule filter for enumeration. The 10-liter samples filtered through a Gelman capsule filter were evaluated in accordance with the procedures indicated in EPA Method 1623. Filter influent and effluent grab samples were taken at initial start up, at the mid-

point of the filter run and at the end of the filter run, just prior to terminal headloss. These seedings allow determination of filter efficacy at several points in the filter cycle. In addition to these challenges, the flow of water through the Kinetico SW224 Filter System was discontinued soon after the midpoint (oo)cyst seeding study during each of the three challenge filter runs. Filter effluent water was directed to an (oo)cyst collection filter over a period of 60 minutes beginning immediately after the resumption of flow though the filter and analyzed for *G. lamblia* cysts and *C. parvum* oocysts. This sequence was termed a "stop/start event".

VERIFICATION OF PERFORMANCE

Source Water

Between March 24 and May 1, 2000, raw water characteristics were: average pH 8.6, temperature 10.3°C, turbidity 0.77 NTU, and total alkalinity 53 mg/L. During the protozoan challenges the raw water characteristics were: average pH 9.2, temperature 11.4°C, turbidity 0.6 NTU, and total alkalinity in the range of 50-52 mg/L.

Operation and Maintenance

The length per filter run varied over the test period, and although the system was not monitored 24 hours per day, a representative filter run at the beginning of the test period was 19.94 hours in length, in the middle of the test period was 17.95 hours and at the end of the test period was 6.50 hours. Recorded total filter run volumes ranged from 5,163 gallons (4/28/00) to 44,347 gallons (3/26/00) per filter run. The filter runs averaged 11.7 hours, with an average of 21,075 gallons per filter run. Continuous monitoring was not required and the technician was not on site during all filter runs; therefore data averages are representative of runs that occurred during technician monitoring. Average calculated flow rate over the test period was 27.98 gpm. The following table is representative of data compiled from two runs selected for the beginning, middle and end run cycles to replicate the data during that time frame.

Average Operating Conditions (March 24 through May 1, 2000)

Test Period Time Frame	Filter Run Time (hrs)	Beginning Flow Rate (gpm)	Ending Flow Rate (gpm)	Change in Pressure (psi)	Gallons Filtered	Backwash Rinse Volume (Gallons)	Backwash Volume (Gallons)	Backwash Flow Rate (gpm)
Beginning	19.94	29.70	28.47	13	34,037	146	287	16
Middle	17.95	30.24	26.52	12	30,847	183	285	16.5
End	6.50	30.15	27.27	11	10,237	157	339	16.8

The Kinetico SW224 Filter System is a packaged water filtration plant designed to provide a continuous process flow and automated to require minimal operator intervention. To support this design two filters are included within the Kinetico SW224 package. When one filter is in operation, the alternate filter is off-line. Filter run time is determined by one of the following events as monitored by the water treatment plant's PLC with timers and sensors/meters installed within the appropriate process stream: Head loss; Turbidity breakthrough; and Time. These values were initially set at 22 psi, 0.5 NTU and 24 hours, respectively. When one of these set-point values is exceeded, the filter run is discontinued and the alternate filter is rinsed and put on-line with minimal interruption in flow. During 50 filter runs that were observed in their entirety, it was noted that the equipment could virtually operate without operator interface.

The only recurring problem with the operation of the Kinetico SW224 filter system involved the on-line turbidimeters supplied with the equipment which required frequent cleaning and verification of calibration.

The O&M manual provided by the manufacturer primarily defined installation, operation and maintenance requirements for Kinetico SW224 Filter System. The manual provided information pertaining to basic installation, start-up, and operational process. A process schematic, trouble shooting guide, and associated O&M manuals for components used within the Kinetico SW224 Filter System were also provided. The O&M manual was reviewed for completeness and used during equipment installation, start-up, system operation, and trouble-shooting. It was found the manual provides adequate instruction for tasks required to perform these functions over the period of operation of the ETV test period. In cases where the operator desired to confirm his interpretation of instructions within the O&M manual, Kinetico's customer support department proved to be responsive.

Protozoan Contaminant Removal

The system demonstrated 1.6 to 3.7 $\log_{10}$ reductions of *G. lamblia* cysts and 0 to 0.8 $\log_{10}$ reductions of *C. parvum* oocysts. These results were obtained at an average flow rate of 28.4 gpm. Analysis of filter effluent samples suggest *G. lamblia* cysts and *C. parvum* oocysts were released from the filter bed as a result of the stop/start event. The number of (oo)cysts detected in the filter effluent during the stop/start event were considerably lower than the number detected during the midpoint seeding challenges and may be further reduced by lengthening the filter-to-waste.

Finished Water Quality

The average effluent turbidity during the 32½day verification testing period was 0.23 NTU. The average effluent turbidity during the protozoan challenges was 0.17 NTU. A summary of the influent and effluent water quality information for the verification period of March 24 through May 1, 2000 is presented in the following table.

Influent/Effluent Water Quality (March 24-May 1, 2000)

Parameter	# of Samples	Average	Minimum	Maximum
Total Alkalinity (mg/L)	6/6	53/54	47/49	62/63
Total Hardness (mg/L)	6/6	80/78	74/73	88/87
TOC (mg/L)	6/6	6.4/6.4	6.1/6.1	6.5/6.6
UVA_{254} (cm^{-1})	6/6	0.098/0.098	0.082/0.086	0.108/0.106
Iron (mg/L)	6/6	<0.1/<0.1	<0.1/<0.1	<0.1/<0.1
Manganese (mg/L)	6/6	0.01/<0.01	0.01/<0.01	0.02/0.01
pH	34	8.6/NA	7.2/NA	9.5/NA
Temperature (C)	34	10.3/NA	7.1/NA	15.4/NA
Free Chlorine (ppm)	11	0.78/NA	0.27/NA	1.48/NA

Notes: All calculations involving results with below PQL values used 1/2 the PQL in the calculation.
Effluent samples were not analyzed for pH, temperature or free chlorine.

Power Consumption

During the 32½day verification testing period the Kinetico SW224 Filter System unit used 147 kWh for 1,307,850 gallons of water filtered. This equates to 8,897 gallons of filtered water per kWh.

Original Signed by
Frank Princiotta for
E. Timothy Oppelt *07/25/01*

E. Timothy Oppelt Date
Director
National Risk Management Research Laboratory
Office of Research and Development
United States Environmental Protection Agency

Original Signed by
Gordon Bellen *07/26/01*

Gordon Bellen Date
Vice President
Federal Programs
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 a NSF Certification of the specific product mentioned herein.

Availability of Supporting Documents

Copies of the *ETV Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants* dated May 14, 1999, the Verification Statement, and the Verification Report (NSF Report # 01/11/EPADW395) are available from the following sources:
(NOTE: Appendices are not included in the Verification Report. Appendices are available from NSF upon request.)

1. Drinking Water Treatment Systems ETV Pilot Manager (order hard copy)
   NSF International
   P.O. Box 130140
   Ann Arbor, Michigan 48113-0140
2. NSF web site: http://www.nsf.org/etv (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)