THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**DIATOMACEOUS EARTH PRESSURE TYPE FILTER USED IN DRINKING WATER TREATMENT SYSTEMS**
APPLICATION:	**PHYSICAL REMOVAL OF MICROBIOLOGICAL AND PARTICULATE CONTAMINANTS IN DRINKING WATER**
TECHNOLOGY NAME:	**SEPARMATIC™ DIATOMACEOUS EARTH PRESSURE TYPE FILTER SYSTEM MODEL 12P-2**
COMPANY:	**SEPARMATIC™ FLUID SYSTEMS**
ADDRESS:	**7628 WEST FLORIST AVENUE** PHONE: **(414) 466-5200** **MILWAUKEE, WI 53218** FAX: **(414) 466-5200**
WEB SITE:	**http://www.separmatic.com**
EMAIL:	**systems@separmatic.com**

The U.S. Environmental Protection Agency (EPA) supports 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 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.

NSF International (NSF) in cooperation with the EPA operates the Drinking Water Systems (DWS) Center, one of seven technology areas under the ETV Program. The DWS Center evaluated the performance of a diatomaceous earth (DE) pressure type filter system for the reduction of microbiological and particulate contaminants in drinking water. This verification statement provides a summary of the test results for the Separmatic™ Fluid Systems DE Pressure Type Filter System Model 12P-2. The verification report contains a comprehensive description of the test. The University of New Hampshire (UNH), an NSF-qualified field testing organization (FTO), performed the verification testing.

ABSTRACT

The verification test of the Separmatic™ DE Pressure Type Filter System Model 12P-2 was conducted at the UNH Water Treatment Technology Assistance Center (WTTAC) in Durham, New Hampshire. Testing occurred between March 10 and May 28, 2003. The source water was finished water from the Arthur Rollins Treatment Plant that was pretreated with a 15 micron (µm) string pre-filter and stored in tanks prior to use as feed water to the system. This water source represented the high-quality water that DE systems are designed to treat. The system was operated with a 0.2 pounds per square foot (lb/ft^2) precoat of Hyflo Super Cel DE and a body feed of 2 milligrams per liter (mg/L) of Celite® 503 DE during the verification test. The system was operated for approximately 360 hours over 22 filter runs. The filter runs averaged approximately 16 hours in duration. The average flow rate ranged from 1.54 to 1.78 gallons per minute (gpm). Initial differential pressure averaged 7.9 pounds per square inch (psi), while ending differential pressure averaged 24.7 psi. The average feed water cumulative (2 to >15 µm) particle counts during the verification test were 47 counts per milliliter (mL), and the average effluent cumulative particle counts were 8 counts per mL. The average feed water online turbidity reading was 0.20 nephelometric turbidity units (NTU), and the average effluent turbidity reading was 0.13 NTU. During three of the filter runs, an initial *Cryptosporidium* oocyst challenge was performed during the first 1.5 hours of operation, and a second challenge was performed at 85% of terminal headloss (approximately 21 psi) during the filter run. The results of the six *Cryptosporidium* oocyst challenges indicated oocyst log_{10} removals ranging from 3.1 to 5.2 with an average of 4.2.

TECHNOLOGY DESCRIPTION

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

The equipment tested in this ETV test was the Separmatic™ DE Pressure Type Filter System Model 12P-2, serial number EXP-5. The system is a small, portable DE pressure filter unit specifically targeted for applications requiring a relatively small flow rate, such as a common supply for a small number of residences, a campground, or a small commercial operation. The system's maximum operating pressure is rated at 100 psi, but typical maximum differential pressures are 20 to 30 psi. The system is rated by the manufacturer to have 2 ft^2 of effective filter area. The system is designed to filter up to 1 gallon per minute per foot square (gpm/ft^2) or 2 gpm. Power requirements for the system are 115 volts, at 19.4 amps under full load.

The system has two tubular, plastic filter elements, each approximately 3.75 inches in diameter and 12 inches long, that are housed in a steel pressure vessel. A nylon septa in a tight weave covers the plastic filter elements. The pressure vessel has four glass portals through which the septa may be visually inspected during operation. The raw water feed connection to the system is a valved 1.25-inch PVC pipe leading to the recirculation pump. The recirculation pump is a Sta-Rite Model PLBC-178L, with a 3/8-inch PVC discharge line. The pump is powered by a 0.5 horsepower (HP) single-phase motor, operating at 3450 revolutions per minute (rpm). The full service load rating of the motor is 13.4 amps for 115 volts or 6.7 amps for 230 volts.

The system's precoat mixing vessel is an open-ended steel cauldron 18-inches in diameter and 18 inches deep. The precoat slurry is mixed by an electric mixer mounted on the precoat tank. The precoat tank is connected to the recirculation pump, and finally to the filter vessel by means of 1.25-inch diameter PVC pipes. The body feed for the system was pumped from a 100 gallon body feed tank with an outlet and mixer supplied by Separmatic™. The body feed was mixed with a Dayton 1/3 HP mixer rated at 276 rpm and pumped using a Masterflex Pump Model 7520-10 with an Easy Load II head.

The system is equipped with a drain box to catch the spent DE filter cake. The box is 14 inches square by 10 inches deep, and is designed to hold a filter bag, which will retain the spent filter cake while the flushing water is drained off.

The components of the system, except for the body feed tank, are bolted or welded onto a steel angle-iron frame. The frame is outfitted with industrial-grade casters, making the unit portable. The overall footprint of the system, except for the body feed tank, is 36 inches by 66 inches. The construction is rugged, and the unit has an estimated weight of 500 pounds (lbs). The system can be loaded into a standard pick-up truck for transport.

The DE used as precoat during the verification test was Hyflo Super Cel DE. According to the technical data sheet provided by the DE manufacturer, Hyflo Super Cel DE is a flux-calcined filter aid made from plankton marine diatomite and has a median cake pore size of 7.0 µm, pH of 10, dry density of 10 pounds per feet cubed (lbs/ft^3), and is in powder form. Celite® 503 DE was used as the body feed during the test. According to the technical data sheet provided by the DE manufacturer, Celite® 503 DE is a flux-calcined filter aid made from plankton marine diatomite and has a median cake pore size of 10.0 µm , pH of 10, dry density of 12 lbs/ft^3, and is in powder form.

VERIFICATION TESTING DESCRIPTION

Test Site

The verification test site was the UNH WTTAC high bay, room 147 of Gregg Hall located at 35 Colovos Road in Durham, New Hampshire. The source water for the verification test was finished water from the Arthur Rollins Treatment Plant, which serves both the Town of Durham and the University of New Hampshire. The treatment plant obtains its water from a reservoir on the Oyster River. The source water was pretreated with a 15 µm string pre-filter as it entered the UNH WTTAC high bay and prior to collection in the feed and challenge tanks used during verification test. The pre-filter was used to assist in the provision of consistent water for treatment.

Methods and Procedures

Onsite bench-top analyses of temperature, pH, turbidity, and dissolved oxygen (DO) were conducted daily for the feed and effluent water according to *Standard Methods for the Examination of Water and* Wastewater.[1] Weekly analyses for total organic carbon (TOC) and ultraviolet light absorbance at 254 nanometers (UV_{254}) were performed by the UNH WTTAC Laboratory. Analyses for iron and manganese were performed by Analytics Environmental Laboratory, LLC. Laboratory analyses for TOC, UV_{254}, iron, and manganese were also performed according to *Standard Methods* [1]. Online particle counters and turbidimeters continuously monitored both the feed water and effluent water, and these data were recorded every five minutes. Particle counters were configured to enumerate particle counts in the following size ranges: total (>2 µm), 2-3 µm, 3-5 µm, 5-7 µm, 7-10 µm, 10-15 µm, and >15 µm. Six *Cryptosporidium* oocyst challenges and one control challenge were performed during the ETV test. The *Cryptosporidium* oocyst analyses were performed by CH Diagnostic and Consulting Service, Inc. of Loveland, Colorado using EPA Method 1623.

Complete descriptions of the verification test results and quality assurance/quality control (QA/QC) procedures are included in the verification report.

[1] APHA, AWWA, and WEF. *Standard Methods for the Examination of Water and Wastewater*, 20th edition. Washington, DC, 1999.

VERIFICATION OF PERFORMANCE

System Operation

Initial test runs were performed during February 2003 to determine the optimum precoat and body feed rates to be used during the verification test. It was determined during the initial test runs that the system would be operated with a 0.2 lb/ft^2 precoat of Hyflo Super Cel DE and a body feed of 2 mg/L of Celite® 503 DE during the verification test.

The verification test of the pressure DE system was initiated on March 10, 2003, and the system was operated continuously through March 28, 2003. The system was operated again prior to and during the *Cryptosporidium* oocyst challenge testing in May 2003. The system was operated for 22 filter runs totaling 359.9 hours, which exceeded the ETV requirement for 272 hours of verification testing. The filter runs averaged 16.4 hours, with the longest duration filter run at 25.4 hours and the shortest duration filter run at 10.4 hours. Initial differential pressure averaged 7.9 psi while ending differential pressure averaged 24.7 psi. The average flow rate ranged from 1.54 to 1.78 gpm. Over the approximately 360 hours of operation, the unit produced a total of 35,531 gallons of treated water.

Water Quality Results

The feed and effluent water were analyzed daily on site for DO, pH, and temperature. Similar concentrations for DO and pH were consistently recorded for the feed and effluent. The feed water averaged 6.1 mg/L O_2 for DO and the median pH was 8.61 pH units. The effluent water averaged 6.2 mg/L O_2 for DO and the median pH was 8.67 pH units. The temperature of the feed water was consistently lower than the effluent, with average values of 10.4 and 11.6 ^oC, respectively.

The feed and effluent water were periodically tested for total iron, total manganese, TOC, and UV_{254}, and no appreciable differences were detected between the feed and effluent water sample results. The feed water averaged <0.06 mg/L for total iron, <0.05 mg/L for total manganese, 2.47 mg/L for TOC, and 0.039 absorbance units per cm for UV_{254}. The effluent water averaged <0.06 mg/L for total iron, <0.05 mg/L for total manganese, 2.45 mg/L for TOC, and 0.039 absorbance units per cm for UV_{254}.

Particle count and turbidity readings were recorded by online Supervisory Control and Data Acquisition (SCADA) instrumentation every five minutes during the 22 filter runs. At the start of filter runs, effluent particle count and turbidity data often showed elevated particle counts and turbidities relative to the feed water values. After 5 to 10 minutes these elevated readings would quickly decrease to consistently lower readings. The elevated initial readings could be the result of inactivity in the effluent lines or residual particles from the precoat process, or they could be a by-product of the transition from recirculation during precoating to feed water flow through the system or the fine tuning of flow through the particle counters. Separmatic™ recommends that the initial effluent water either be wasted or re-circulated to the feed to maximize effluent water quality. Therefore, the particle count and turbidity SCADA data from the initial 5 to 10 minutes of filter runs were not included in the operational performance evaluation or water production runtime.

The average feed water cumulative (2 to >15 µm) particle counts during the test period were 47 counts per mL, and the average effluent cumulative particle counts were 8 counts per mL. The particle count data showed an 83% removal for cumulative particles. The average feed water online turbidity reading was 0.20 NTU, and the average effluent reading was 0.13 NTU.

Microbial Challenge Results

A *Cryptosporidium* control challenge was performed on March 24, 2003. The control challenge without precoat or body feed indicated 6.2 log_{10} of *Cryptosporidium* oocysts in both the feed and the effluent, demonstrating that oocysts were not removed by the system hardware, plastic filter elements, or septa.

Three sets of two *Cryptosporidium* challenge tests occurred on May 14, May 19-20, and May 28 of 2003. In each, an initial challenge was performed during the first 1.5 hours of operation and a second challenge was performed at the 85% mark of the filter run, commencing when a pressure differential of approximately 21 psi was reached. The removal of oocysts averaged 4.2 ± 0.9 log_{10} for the six challenges with log_{10} removals ranging from 3.1 to 5.2. The data for the three sets of challenges show the 1.5 hour challenges averaged 4.4 ± 0.9 log_{10} removals and the 85% challenges averaged log removals of 3.9 ± 0.9 log_{10}. The results indicate that the removal of *Cryptosporidium* oocysts was not substantially affected by whether the challenge was conducted at the beginning or the end of a filter run. A summary of the *Cryptosporidium* challenge data is provided in Table VS-1.

Table VS-1. *Cryptosporidium* Oocyst Challenge Test Sample Results

Set No.	Date	Time Description	Average Feed Oocysts (#/20L)	Average Effluent Oocysts (#/20L)	Log_{10} Removal Oocysts
1	5/14/03	1.5 hours	2.2 x 10^6	891	3.4
1	5/14/03	85% Headloss	1.5 x 10^6	1270	3.1
2	5/19/03	1.5 hours	1.6 x 10^6	38	4.6
2	5/20/03	85% Headloss	2.0 x 10^6	32	4.8
3	5/28/03	1.5 hours	2.8 x 10^6	19	5.2
3	5/28/03	85% Headloss	2.0 x 10^6	381	3.7

Operation and Maintenance Results

The operation of the system, which included preparing precoat and body feed, monitoring operations, collecting readings, and performing analyses, averaged approximately four hours per day during normal operational runs, not including the time spent performing the *Cryptosporidium* challenges.

During shakedown testing before the start of verification test, modifications were made in the operating procedures following a Separmatic™ representative's visit to the test site in February 2003. The representative brought and installed two new filter elements. The precoating procedure was modified to take place in two steps, with an initial period of precoat flow of 1.5 times target flow followed by a shorter period of target flow to allow the precoat to settle into its intended structure on the DE filter elements. The representative had a pressure differential safety switch sent to UNH for installation, which shut off the system when the pressure differential reached a maximum level. The representative also had a 2.0 gallons per minute flow controller sent to UNH to replace the needle valve shipped with the system.

Separmatic™ provided an operation and maintenance manual (O&M) for the system. The manual included four chapters covering assembly of the system, instructions for pressure filter start-up, precoat filtration, and filtration and backwash procedures. The manual also provided a schematic drawing of the system, a parts list, and equipment O&M manuals for the components of the system. The operating instructions were simple and easy to follow. The O&M manual did not include directions for body feed or the replacement of the septa or the filter bags, which Separmatic™ may wish to perform as a company policy. Separmatic™ provided verbal instructions for these items. UNH requested written body feed instructions from Separmatic™. These were provided and are included in the verification report.

Consumables and Waste Generation

A total of 9.49 lbs of DE was used for precoat and body feed during the 22 filter runs. The unit consumed 9.5 kilowatt-hour (kW-hr) of energy per 1000 gallons of treated water produced.

For the ETV test, the spent DE in the drain box was transferred to a barrel container and allowed to settle. Liquid from the container was decanted and discharged to the Durham sewer system. The spent DE remaining in the container was disposed in an approved landfill.

Quality Assurance/Quality Control

NSF provided technical and quality assurance oversight of the verification test as described in this verification report, including an audit 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		*Original Signed by*	
Lawrence W. Reiter	*9/20/04*	*Gordon Bellen*	*9/23/04*
Lawrence W. Reiter	Date	Gordon Bellen	Date
Acting Director		Vice President	
National Risk Management Research Laboratory		Research	
Office of Research and Development		NSF International	
United States Environmental Protection Agency			

Availability of Supporting Documents

Copies of the *ETV Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants*, dated April 20, 1998 and revised May 14, 1999, the verification statement, and the verification report (NSF Report #04/01/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 (electronic copy)
3. EPA web site: http://www.epa.gov/etv (electronic copy)