THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**POINT-OF-ENTRY DRINKING WATER TREATMENT SYSTEM**
APPLICATION:	**REMOVAL OF MICROBIAL CONTAMINANTS IN DRINKING WATER**
PRODUCT NAME:	**HF-82-35-PMPW™ ULTRAFILTRATION MEMBRANE**
VENDOR:	**KOCH MEMBRANE SYSTEMS, INC.**
ADDRESS:	**850 MAIN STREET WILMINGTON, MA 01887**
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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 Koch Membrane Systems, Inc. HF-82-35-PMPW Ultrafiltration (UF) Membrane. 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

Two Koch Membrane Systems HF-82-35-PMPW™ UF membrane cartridges were tested for removal of viruses, bacteria, and protozoan cysts at NSF's Drinking Water Treatment Systems Laboratory. The testing was conducted as part of a series of ETV verifications of the US Navy Office of Naval Research's Expeditionary Unit Water Purifier (EUWP), manufactured by Village Marine Tec. The tests reported herein served to demonstrate the performance of the Koch Membranes Targa®-10-48-35-PMC UF membrane cartridge used in the EUWP. The Targa-10-48-35-PMC is a larger version of the HF-82-35-PMPW; both cartridges are made with the same UF membrane fibers. For this verification, the HF-82-35-PMPW was operated at a target flux of 40 gallons per day per square foot (gfd), which is the operating flux of the Targa-10-48-35-PMC in the EUWP. This verification did not address long-term performance, membrane cleaning, or full-scale field maintenance and operation issues. These items will be addressed in the verification reports for the full EUWP.

The UF cartridges were challenged with approximately 5 $\log_{10}$ of the bacteriophage viruses fr and MS2, 7 to 8 $\log_{10}$ of the bacteria *Brevundimonas diminuta*, and 5.7 $\log_{10}$ of live *Cryptosporidium parvum* oocysts. The bacteria and viruses used in this study served as surrogates for pathogenic bacteria and viruses that may be introduced into drinking water through accidental or intentional contamination. Each challenge was 30 minutes in length. The membranes removed a minimum of 4.8 $\log_{10}$ of the viruses, 6.0 $\log_{10}$ of *B. diminuta*, and 5.7 $\log_{10}$ of *C. parvum*.

TECHNOLOGY DESCRIPTION

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

The Koch HF-82-35-PMPW is 5" x 43" UF membrane cartridge. The membrane fibers are made of polysulfone, with a nominal fiber inner diameter of 0.9 millimeters. The nominal membrane surface area for the cartridge, using the fiber inner diameter, is 82 square feet. The nominal molecular weight cutoff rating for the membrane is 100,000 Daltons.

This verification was conducted as part of a series of ETV verifications of the US Navy Office of Naval Research's EUWP, manufactured by Village Marine Tec. The tests served to demonstrate the performance of the Koch Membrane Systems Targa-10-48-35-PMC UF membrane cartridge used in the EUWP. The Targa-10-48-35-PMC is a larger version of the HF-82-35-PMPW; both cartridges are made with the same UF fibers.

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 February and March of 2006.

Methods and Procedures

The testing methods and procedures are detailed in the *Test/QA Plan for the Microbial Seeding Challenge Study of the Koch Membrane Systems HF-82-35-PMPW UF Membrane*. Two membrane cartridges were challenged with the bacteriophage viruses fr and MS2, the bacteria *B. diminuta*, and live *C. parvum* oocysts. The challenge bacteria and viruses 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 (KanR *B. diminuta*). This allowed the Microbiology Laboratory to use a growth media amended with 50 micrograms per liter

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

The target challenge concentrations for each organism were as follows:

- MS2 and fr: $\geq 1x10^4$ plaque forming units per milliliter (PFU/mL);
- *B. diminuta*: $\geq 1x10^6$ colony forming units per 100 milliliters (CFU/100 mL); and
- *C. parvum*: $\geq 1x10^5$ oocysts per liter.

Prior to each challenge, an air bubble leak-check test procedure provided by Koch Membranes was conducted. Approximately five pounds per square inch, gauge (psig) of air was applied to the filtrate side of the membrane cartridge for five minutes, with the inlet port closed, but the reject port open. The degree to which air bubbles rose from the membrane fibers indicated whether any fibers were compromised. A steady stream of air bubbles would be indicative of a leak in a fiber.

The Targa-10-48-35-PMC membrane in the EUWP is operated at a flux of 40 gfd, with a reject flow rate of 10% of the feed flow. To approximate these operation conditions, the target feed flow rate for the HF-82-35-PMPW was 2.5 gallons per minute (gpm), and the target filtrate flow rate was 2.3 gpm.

The membranes were challenged with each organism for 30 minutes. Separate challenges were conducted for each organism. Feed and filtrate samples were collected for challenge organism enumeration at start-up, after 15 minutes of operation, and after 30 minutes of operation. All samples were analyzed in triplicate.

VERIFICATION OF PERFORMANCE

The results of the microbial challenges are presented below in Table VS-1. The measured triplicate feed and filtrate counts were averaged by calculating geometric means. The mean organism counts for each sample point were then averaged to give an overall mean count for the challenge. These counts were log_{10} transformed, and log reductions were calculated for each challenge.

Table VS-1. Mean Challenge Organism Reduction Data

	Feed		Cartridge 1 Filtrate			Cartridge 2 Filtrate		
Challenge	Geometric Mean (PFU/mL)	Log_{10}	Geometric Mean (PFU/mL)	Log_{10}	Log_{10} Reduction	Geometric Mean (PFU/mL)	Log_{10}	Log_{10} Reduction
fr	$6.7x10^4$	4.8	1	0.0	4.8	1	0.0	4.8
MS2	$6.7x10^4$	4.9	1	0.0	4.9	1	0.0	4.9
Challenge	Geometric Mean (CFU/100mL)	Log_{10}	Geometric Mean (CFU/100mL)	Log_{10}	Log_{10} Reduction	Geometric Mean (CFU/100mL)	Log_{10}	Log_{10} Reduction
B. diminuta	$8.2x10^7$	7.9	1	0.0	7.9	1	0.0	7.9
KanR *B. diminuta*	$5.4x10^7$	7.7	1	0.0	7.7	52	1.7	6.0
KanR *B. diminuta* retest for Unit 2	$1.2x10^7$	7.1	—	—	—	2	0.3	6.8
Challenge	Geometric Mean (oocysts/L)	Log_{10}	Geometric Mean (oocysts/L)	Log_{10}	Log_{10} Reduction	Geometric Mean (oocysts/L)	Log_{10}	Log_{10} Reduction
C. parvum	$5.3x10^5$	5.7	<1	0.0	5.7	<1	0.0	5.7

Note that the KanR *B. diminuta* challenge was conducted twice on Cartridge 2. This was due to the relatively high effluent counts measured during the first KanR *B. diminuta* challenge compared to the cartridge's performance in the other challenges. To check for any membrane integrity issue that could have caused the high effluent counts, the membranes were subjected to an air pressure decay test as

described in *ASTM D6908-03, Standard Practice for Integrity Testing of Water Filtration Membrane Systems*. The data is presented below in Table VS-2. The pressure decay rate for Cartridge 1 was measured to be 0.11 pounds per square inch, gauge, per minute (psig/min). The measured pressure decay rates for Cartridge 2 were 0.14 and 0.29 psig/min. Koch Membrane Systems provided an estimated severed fiber pressure decay rate of 2.1 psig/min for the HF-82-35-PMPW membrane, so the measured decay rates for Cartridge 2 are not indicative of a breach in membrane integrity. Also, the air bubble leak-check tests did not indicate that any membrane fibers were compromised during testing.

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 100% of the data. NSF QA 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 09/22/06
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Availability of Supporting Documents
Copies of the test protocol, the verification statement, and the verification report (NSF report # NSF 06/24/EPADWCTR) are available from the following sources:

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/info/etv
   EPA web site: http://www.epa.gov/etv