THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency | **NSF International**

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Decontamination Wastewater Treatment**	
APPLICATION:	**Homeland Security**	
TECHNOLOGY NAME:	**UltraStrip Systems, Inc. Mobile Emergency Filtration System**	
TEST LOCATION:	**EPA Test & Evaluation Facility, Cincinnati, Ohio**	
COMPANY:	**UltraStrip Systems, Inc.**	
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NSF International (NSF) manages the Water Quality Protection Center (WQPC) under the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) Program. NSF evaluated the performance of the UltraStrip™ Systems, Inc. (USS) Mobile Emergency Filtration System (MEFS), a portable modular wastewater treatment device designed to remove solids, chlorine, organics, pesticides, and metals from wastewater. Testing was completed at the EPA's Test & Evaluation Facility in Cincinnati, Ohio, which is operated by Shaw Environmental, Inc. Testing was conducted from November 19, 2003 through January 5, 2004.

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.

TECHNOLOGY DESCRIPTION

The following technology description is provided by the vendor and was not represent verified information.

UltraStrip Systems, Inc., an ISO 9001-registered company, manufactures the patent-pending MEFS. The MEFS is an easily portable, self-contained wastewater treatment system designed for treating wastewater generated from decontamination of sites contaminated by biological or chemical agents. The MEFS utilizes multiple treatment processes to neutralize or remove contaminants in the wastewater and has the capacity to treat approximately 26 gallons per minute (100 Lpm) on a batch or continuous flow basis.

The MEFS includes the following unit processes:

- Chlorine removal system (CRS) for chemical neutralization (dechlorination);
- Centrifuge for solids removal;
- Media filtration, including sand and activated carbon to remove small particles and dissolved organic compounds, and Bayoxide E33, a granular filter media formulated to remove metals;
- Ultrafiltration (UF) to remove fine particulates; and
- Reverse osmosis (RO) to remove very fine particulates, large microorganisms, and dissolved salts.

The MEFS is equipped with valves and piping to provide flexibility in operation so that individual unit processes can be bypassed. The system is also equipped with meters to monitor various performance parameters, such as flow rates, reject rates, pressures, and water temperatures. USS claims that the system will treat wastewater from decontamination operations involving highly chlorinated water or chemical agent contamination, to meet surface water discharge or reuse criteria.

VERIFICATION TESTING DESCRIPTION

Methods and Procedures

The testing methods and procedures used during the testing are detailed in the *Verification Test Plan for Treatment of Wastewater Generated During Decontamination Activities, UltraStrip Systems, Inc. (October, 2003)*. Three separate 10-day test phases were completed, during which the MEFS was challenged with a wastewater mixture including partially-treated sewage, used motor oil, surfactants, sediments, and a primary constituent of concern, depending on the testing phase:

- Trivalent arsenic, to simulate decontamination wastewater from an inorganic chemical agent (Lewisite) event;
- Methyl parathion, to simulate decontamination wastewater from an organic chemical nerve agent event; and
- Sodium hypochlorite (bleach), to simulate decontamination wastewater from a biological agent event, where chlorine dioxide and bleach were used to disinfect the affected area.

During each test day, influent and effluent samples were collected and analyzed for the primary constituents, secondary fouling parameters, and water quality indicator parameters. Primary analytical parameters included total arsenic, organo-phosphorous pesticides, and free and total chlorine. Secondary analytical parameters consisted of alkalinity, surfactants (MBAS), oil and grease (O&G), total suspended solids (TSS), 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), ammonia, total Kjeldahl nitrogen (TKN), and total phosphorus. Indicator parameters included pH, turbidity, and temperature. The system was evaluated to determine maximum flow rate, bypass flow rates from the UF and RO systems, ease of setup and installation, and operation and maintenance requirements.

Complete descriptions of the verification testing results and quality assurance/quality control procedures are included in the verification report.

PERFORMANCE VERIFICATION SUMMARY

System Installation, Operation, and Maintenance

The system was delivered to the site on a flatbed trailer and was inspected by USS personnel to ensure that system components were not damaged during shipping. The system underwent a wet test with clean water to check that it was watertight and operating properly. After USS personnel performed a few minor piping adjustments to accommodate the testing facility, the system was ready for operation.

Maintenance during testing consisted primarily of filling treatment chemical containers, replacing filter pads or activated carbon, and daily backwashing of the media filters. Backwashing took approximately 30 minutes and consisted of running clean water through the treatment processes and the clean-in-place loop, then running the rinseate water back through the treatment processes.

USS provided three equipment operators to operate the system during testing. Two operators were required to run the system, while the third provided backup or general assistance.

When used, the CRS system restricted the pumping ability of the primary influent pump, and an auxiliary pump was required to maintain rated flow rates. No other operational issues with the MEFS were noted.

Flow Capacity

The wastewater was mixed each morning in a tank supplied by the testing organization with a nominal volume of 10,000 gallons, and an operating volume of approximately 9,100 gallons. Due to the configuration of the piping hookups on the influent supply tank, the MEFS was unable to pump the last five inches (approximately 500 gallons) out of the bottom of the tank. Therefore, during each test day the MEFS treated approximately 8,600 gallons of wastewater.

The influent and bypass volumes and operating duration times were recorded for each test day, and were used to calculate the treated effluent volume and the average daily flow rate. During most test days, the MEFS achieved a flow rate ranging from approximately 21 to 24 gallons per minute (gpm), just below the system's rated capacity of 26 gpm (100 Lpm). There were two situations where decreased flow rates were noted. During the first four days of the inorganic chemical event test, when the centrifuge was bypassed, flow rates decreased to a range of 15 to 18 gpm. After the media filters were backwashed and the centrifuge brought on-line, the flow rate recovered. Also, the flow rate decreased steadily during the organic chemical event test, from an initial flow rate of 23 to 24 gpm to a final flow rate of 21 to 23 gpm.

Treatment Capability

Inorganic chemical event—The centrifuge (during the first four test days), CRS, and RO processes were bypassed for this test event. Decreased flow rates prompted USS to utilize the centrifuge in the final six days of the test event.

The target influent arsenic concentration was 5 mg/L, and the actual arsenic concentration ranged from 4.0 to 5.7 mg/L, with a mean of 5.0 mg/L. The effluent arsenic concentration was below detection limits (<0.010 mg/L) for the first four days of test event, and incrementally increased from 0.02 to 0.06 mg/L during the fifth through tenth days. This resulted in a mean treatment efficiency greater than 99.6 percent.

Organic chemical event—The CRS, Bayoxide E33 media filter, and RO processes were bypassed during this test event. The target influent concentration for methyl parathion was 1 mg/L.

The influent methyl parathion concentration ranged from 0.55 to 0.93 mg/L and averaged 0.72 mg/L. The effluent concentration increased incrementally from 0.00028 to 0.013 mg/L over the course of the test event, resulting in treatment efficiencies that ranged from 98.4 to greater than 99.9 percent, and averaged greater than 99.4 percent.

Biological agent event—Only the Bayoxide E33 media filter process was bypassed for this test event.

Effluent samples collected from the water treated by the RO process were analyzed for free chlorine, while samples for the rest of the analytical parameters were collected from the RO bypass. On one test day, effluent samples were collected from both the RO effluent and RO bypass. The target influent concentration for free and total chlorine was 5,000 mg/L as Cl_2.

The influent free chlorine and total chlorine concentration ranged from 3,700 to 6,700 mg/L (averaging 5,500 mg/L), with the free and total chlorine concentrations being essentially equal. The effluent free chlorine concentrations were below detection limits (<0.02 mg/L) for 13 of 20 samples, with the remaining seven samples ranging from 0.02 to 0.14 mg/L. The total chlorine detection limit (0.10 mg/L) was five times higher than the free chlorine detection limit. Since the effluent free chlorine concentration exceeded the total chlorine detection limit on only one sample (0.14 mg/L), the TO did not analyze the effluent for total chlorine.

Secondary and indicator parameters—The secondary and indicator parameters did not vary significantly between the three test events. Table 1 summarizes the secondary analytical parameters. The MEFS raised the water temperature by approximately 2°C, pH remained neutral, and turbidity dropped by approximately 74 to 87 percent.

Table 1. Secondary Analytical Parameter Summary

Parameter	Mean Influent Concentration (mg/L)	Treatment Efficiency (Percent) [1] Inorganic	Organic	Biological
Alkalinity	1,700	46	35	95 [3]
BOD_5	46	89	77	69 [2]
COD	48	81	71	-2,800 [2]
MBAS	0.86	62	21	-33
Ammonia (as N)	13	16	-2.4	33
Oil & Grease	7.0	48	58	72
TKN (as N)	11	7.8	-2.1	-110
Total phosphorus (as P)	1.1	98	78	61
TSS	23	92	77	52

[1] One-half the method detection limit was used when concentrations were below detection limits.
[2] The chlorinated and dechlorinated BOD_5 and COD samples were flagged as unreliable.
[3] Sodium hypochlorite is dissolved in an alkaline solution which is neutralized during dechlorination.

UF and RO Reject Flow Rates

The reject flows generated by the UF and RO processes were monitored and discharged to the test site's sewer, in compliance with facility-specific permit requirements. In the field, reject water likely would be pumped back to the influent storage tank for retreatment. During the inorganic chemical event test, the UF reject flow ranged from 6 to 16 percent of the influent volume, with no distinct trend or pattern. During the organic chemical event test, the UF reject flow started at approximately 9 percent, and increased to 12 to 14 percent by the end of testing. During the biological event test, when both the UF and RO processes were used, the reject flow ranged from 53 to 74 percent.

Consumables and Waste Generation

Over the course of the three test events, the MEFS consumed an average of approximately 180 kilowatt hours (kWh) of electricity per test day, and ranged from 113 to 221 kWh, and the system was run an average of 6.5 hours. The lowest readings were recorded during the first four days of the inorganic chemical event test, when the centrifuge was not run.

During the biological event test phase, CRS (calcium thiosulfate) was used for dechlorination. The MEFS used between 88 and 160 gallons and averaged 120 gallons of CRS per test day, and 34 to 90 liters of sodium hydroxide to maintain a caustic pH. During all three test phases, the MEFS used muriatic

(hydrochloric) acid (50 to 1,000 mL/day), 50 percent alum flocculent (4 to 5 L/day), and a UF/RO membrane cleaner (6 L total) in the treatment process.

Over the course of the three test events, the MEFS generated 52 pounds (dry weight) of used oil-sorbent pads, which were located before the centrifuge to prolong the functionality of the activated carbon. The centrifuge generated 163 pounds of sludge. The activated carbon was replaced after both the inorganic chemical event and the organic chemical events. The spent carbon filled two 55-gallon drums per change out. These waste materials were classified non-hazardous, as determined by TCLP testing.

RO Membrane Integrity Test

The RO membrane and housing were evaluated using a pressure decay test to determine the physical integrity of the process. The test procedures are outlined in the American Society for Testing and Materials (ASTM) Designation D 6908-03, "Standard Practice for Integrity Testing of Water Filtration Membrane Systems, Practice A—Pressure Decay and Vacuum Decay Tests." The test estimates the ability of an RO system to reject particles in the one to two micron range. Tests were run before and after the biological event test phase and the results were used to assess whether processing the dechlorinated wastewater through the RO system impaired its treatment capabilities. The test results showed that the system could achieve a 3.7 log reduction for 1.4 micron particles, and that the wastewater did not impair the RO system.

Quality Assurance/Quality Control

NSF personnel completed a technical systems audit during testing to ensure that the testing was in compliance with the test plan. NSF also completed a data quality audit of at least 10 percent of the test data to ensure that the reported data represented the data generated during testing. In addition to QA/QC audits performed by NSF, EPA personnel conducted an audit of NSF's QA Management Program.

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Availability of Supporting Documents

Copies of the *Verification Test Plan for Treatment of Wastewater Generated During Decontamination Activities, UltraStrip Systems, Inc., October 2003,* the verification statement, and the verification report (NSF Report #04/14/WQPC-HS) are available from:

ETV Water Quality Protection Center Program Manager (hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140

NSF web site: http://www.nsf.org/etv (electronic copy)
EPA web site: http://www.epa.gov/etv (electronic copy)

Appendices are not included in the verification report, but are available from NSF upon request.