THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**SOLIDS SEPARATOR**	
APPLICATION:	**SEPARATION OF MANURE SOLIDS FROM FLUSHED SWINE WASTE**	
TECHNOLOGY NAME:	**MAXIMIZER SEPARATOR MAX 1016**	
COMPANY:	**BROME AGRI SALES LTD.**	
ADDRESS:	**2389 ROUTE 202** **DUNHAM, QUEBEC J0E 1M0** **CANADA**	**PHONE: (450) 266-5323** **FAX: (450) 266-5708**

NSF International (NSF), in cooperation with the U.S. Environmental Protection Agency (EPA), operates the Water Quality Protection Center under EPA's Environmental Technology Verification (ETV) Program. As part of the Water Quality Protection Center's activities in verifying the performance of source water protection technologies, the ETV Program evaluated the performance of an inclined screen system for separating solids from flushed swine waste. This verification statement summarizes the test results for the Brome Agri Sales Ltd. Maximizer Separator Model MAX-1016 (Maximizer). The verification testing was conducted by North Carolina State University's Biological and Agricultural Engineering Department in Raleigh, North Carolina.

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 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 testing organizations and stakeholder advisory 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 description of the Maximizer separator was provided by the vendor and does not represent verified information.

The Maximizer is an inclined screen solids separator that can be used to separate solids from slurry waste at a flow rate between 20 and 45 gpm or from flushed swine waste at a flow rate up to 90 gpm. The lower end of the inclined screen rests in a stainless steel tank assembly. Wastewater containing manure solids is pumped into the primary tank, which is part of the stainless steel tank assembly. The waste solids are then transported up the inclined screen using a wiping/carrying system consisting of a series of thirty-two rubber paddles attached to chains driven by an electric motor. The inclined screen is made up of two eight-foot long sections, a lower section and an upper section, each with a different sized perforated metal screen. As the waste is transported up the inclined screen, water drains through the perforations to a drip pan, and from there into a secondary tank. Once the thickened waste reaches the top of the screen, it is processed through a squeezing mechanism, consisting of a worm screw followed by a perforated cylinder, for final drying of the removed solids. The system discharges liquid effluent from the top of the secondary tank while additional solid material settles to the bottom of this tank. Periodically, the thickened wastewater collected in the bottom of the secondary tank is pumped back to the primary tank for further solids removal. This was done near the end of every third test day during the verification test.

The following is a summary of the characteristics of the Maximizer Separator:

Type	Inclined screen, bottom feed
Screen length	16 ft
Initial (lower) screen openings	0.031 in
Secondary (upper) screen openings	0.062 in
Maximum capacity	90 gpm

The Maximizer was evaluated while sitting in a MAX-1400 stainless steel tank assembly, with a MAX-1500 stainless steel winching assembly.

Verification Testing Description

Test Site

Verification testing was conducted at the North Carolina State University (NCSU) Lake Wheeler Road Field Laboratory Swine Educational Unit. This farm is designed and operated as a research and teaching facility. The farm capacity is 250 sows for farrow to wean (birth to wean). The farm can finish (grow to a market weight of 250 lb) approximately half of the pigs weaned each year. Under normal operating conditions, waste at the site is removed by flushing under-slat pits with treated wastewater from the on-site anaerobic lagoon. Flushed waste then flows back to the lagoon for treatment. During the verification test, the flushed waste was diverted to a 2,500 gal glass-lined influent mixing tank of 12-ft diameter and 10-ft depth. To minimize aeration and physical changes to the wastewater, the influent mixing tank was equipped with a 5-hp mixer with a 2-ft diameter impeller, designed to keep solids suspended with minimum turbulence.

An all-in/all-out closed loop process was developed to eliminate problems and errors associated with flow measurement and sampling. All of the waste generated over a two-day period was left in the under-slat pits until it was flushed and collected in the influent mixing tank. This wastewater was pumped from the influent mixing tank to the test unit. Liquid discharged from the test unit was collected in the effluent tank, and the separated solids were collected on an adjacent concrete pad.

Methods and Procedures

Verification testing began on Monday, February 12, 2003. Technology evaluation and sampling procedures were carried out three days per week (Monday, Wednesday, and Friday) for four weeks, for a total of twelve testing events.

At the beginning of each test day, the Maximizer was started and the unit was visually inspected to verify that the conveyor was working correctly. Wastewater from the swine unit was collected and mixed in the influent mixing tank to equally distribute solids throughout the tank. Wastewater was typically held in the mixing tank for less than five minutes, but never more than thirty minutes. Wastewater was then pumped to the Maximizer at a nominal flow rate of 80 gallons per minute. The Maximizer effluent pumps were situated in the secondary tank so that the effluent pumped from the system generally did not contain high concentrations of the solids that settled at the bottom of the secondary tank. The thicker material was pumped back to the primary tank four times during the test period, near the end of every third test day. At the conclusion of the final test, the contents of the secondary tank were mixed, the volume was measured, and samples were taken to complete the mass balance.

Measurements made each test day included volume of wastewater entering the unit, volume of the effluent stream, weight of solids discharged through the auger and rollers, and concentrations of quality parameters in each of the sampled components (influent, effluent, and solids). The influent and effluent volumes were determined based on the waste depths and dimensions of each tank. The weight of the solids was determined as the difference in the weights of large containers with and without the solids. Weights were measured at the testing location using appropriate scales. Concentrations of the quality parameters were determined by laboratory analysis of grab samples collected in triplicate. The analyses performed included solids (total, suspended, and volatile), total organic carbon (TOC), nutrients, metals, pH, conductivity, and bulk density. The mean daily values were summed over the test period and converted to mass in order to complete the mass balance. Samples were also collected once per week and analyzed for *E. coli* and total coliform.

Performance Verification

System Performance

The mass balance approach allowed for the determination of the proportion and mass of the recovered solids, and how the nutrients partitioned between the solid and liquid phases. These results are shown in Table 1. For each parameter, the total mass recovered from the Maximizer (effluent and solids) is shown in Table 1 as the percent of the mass in the influent.

Table 1. Partitioning and Recovery of Parameters from Influent

Parameter	Percent In: Recovered Solids	Liquid Effluent	Total (Solids, Effluent)
Dry matter / suspended solids	28	81	109
Total nitrogen	7.4	95	102
Total phosphorus	12	95	106
Potassium	2.3	92	95
Copper	6.6	97	104
Zinc	10	96	106
Chloride	1.4	94	95

Note: The data in Table 1 are based on twelve samples.

The recoveries from the mass balance are ideally within ± 10 percent of 100 for this type of work, although recoveries outside of this range are common due to the complex nature of both the wastewater and separated solids. The data quality indicators for this verification test were all within established limits. Because of this, nothing can or should be inferred from total recoveries not equal to 100 percent.

The characteristics of the liquid effluent and the recovered solids are shown in Tables 2 and 3, respectively. All values presented in the table reflect means calculated over the test period.

Over the entire test period, 833 lb of dry solids were recovered by the Maximizer, representing 28 percent on a mass basis of the 2,990 lb of suspended solids in the influent. The recovered solids contained 18 percent dry matter (82 percent moisture). The remaining solids were released with the effluent stream (81 percent), which had a suspended solids concentration of 9,490 mg/L.

Table 2. Influent / Effluent Characteristics

Parameter	Units	Influent	Effluent
Total solids	mg/L	13,200	11,200
Volatile solids	mg/L	8,950	7,850
Suspended solids	mg/L	11,000	9,490
Total organic carbon	mg/L	2,720	2,750
Total Kjeldahl nitrogen	mg/L	1,030	1,040
Ammonia nitrogen	mg/L	519	515
Total phosphorus	mg/L	378	382
Ortho phosphorus	mg/L	208	214
Potassium	mg/L	472	464
Chloride	mg/L	250	250
Copper	mg/L	6.1	6.3
Zinc	mg/L	10.7	10.9
N:P:K ratio		2.72: 1.00:1.25	2.72:1.00:1.22
pH		7.52	7.47
Conductivity	µmhos/cm	4,640	4,710
Total coliform	MPN/100mL	3.7×10^8	3.9×10^8
E. coli	MPN/100mL	2.3×10^8	2.6×10^8

Note: The data in Table 2 are based on twelve samples.

Operation and Maintenance Results

Operational Observations

One operational problem was encountered during the verification test of the Maximizer. On the last test day, March 14th, solids bridged across the flights of the auger that transfers recovered solids from the top of the screen to the squeezing gates. This blocked the entrance to the auger and prevented solids from transferring to the discharge point. The flow of solids out of the unit ceased. Flow into the unit was then stopped and the unit was shut down for approximately five minutes while the auger was cleaned out by hand. The unit was placed back into operation and the test was completed.

Maintenance Observations

No maintenance was performed on the Maximizer during the verification test period. The screen was not washed during the 30-day test period. A permanent installation would be expected to require some maintenance over time, such as lubricating bearings and washing the screen. The manufacturer's operations manual did not include a routine maintenance schedule.

Table 3. Recovered Solids Characteristics

Parameter	Units	Concentration
Dry matter	percent by weight	17.6
Volatile solids	percent by weight	15.9
Total carbon	percent by weight	7.61
Total nitrogen	percent by weight	0.44
Total phosphorus	µg/g	2,530
Potassium	µg/g	628
Chloride	µg/g	207
Copper	µg/g	22.9
Zinc	µg/g	63.1
Bulk density	g/mL	0.984
Total coliform	MPN/g	4.7×10^8
E. coli	MPN/g	3.4×10^8
N:P:K ratio		1.74:1.00:0.25

Note: The data in Table 3 are based on twelve samples.

Electrical Requirements

The Maximizer required 240 V, single-phase electrical power to operate the two electric motors (totaling five hp). Units for installation with three-phase power and voltages up to 575 V are available. The Maximizer's two motors were wired to the main connection box. Electrical installation consisted of supplying power to the unit and making the appropriate connections at the unit's control panel.

A data logger measured current and voltage and calculated values of kilowatts, which were recorded every ten seconds. The peak power consumption usually occurred when influent was first sent to the unit, and the mean peak power consumption was 2.32 kW. The overall mean power consumption during operation was less than 1.5 kW. During the entire verification test, the Maximizer used approximately 0.37 kW-h of energy per 1,000 gallons of wastewater treated.

Quality Assurance/Quality Control (QA/QC)

During testing, NSF International completed QA audits of the NCSU Biological and Agricultural Engineering Department's Environmental Analysis Laboratory and Swine Educational Unit, Lake Wheeler Road Field Laboratory. NSF personnel completed (1) a technical systems audit to assure the testing was in compliance with the test plan, (2) a performance evaluation audit to assure that the measurement systems employed by the laboratory and the field technicians were adequate to produce reliable data, and (3) a data quality audit of at least ten percent of the test data to assure that the reported data represented the data generated during the testing. In addition to the quality assurance audits performed by NSF International, EPA QA personnel conducted a quality systems audit of NSF International's QA Management Program.

Original signed by		*Original signed by*	
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Availability of Supporting Documents

Copies of the *ETV Test Plan for the Verification of Technologies for Separation of Manure Solids from Flushed Swine Waste,* dated April 2002, the Verification Statement, and the Verification Report are available from the following sources:

ETV Water Quality Protection Center Manager (order hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140
(734) 769-8010

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

NOTE: Appendices are not included in the Verification Report. Appendices are available from NSF upon request.