Statement of Verification

Technology:	SmartScrape
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DANAK
INSP Reg. Nr. 9099
Medlem af EA MLA

Verified according to the ISO Standard 14034
on Environmental Management:
Environmental Technology Verification

1. Technology description

The SmartScrape system is a new scraping system for slurry gutters in mink houses. The system automatically adapts scraping frequency to slurry load. On an average the slurry gutters are emptied every 8th hour to minimize the wet slurry surface which reduces ammonia, odor, and greenhouse gas emissions. Fast removal of slurry from the mink house results in greater nutrient value of the slurry and higher biogas potential. The slurry gutters are made from a special plastic where the slurry does not stick. The system has a level meter alarm that efficiently turns off scraping if the slurry drainage tubes are full. The system adapts the scraping frequency to feeding load which is direct correlated to the slurry load. In the summer period where the slurry load and temperature are high the scraping frequency is up to six times per day, and in the winter season where only the breeding animals are left in the mink houses scraping is reduced to one scraping per day, se the above graph. Scrapings are evenly distributed over one day.

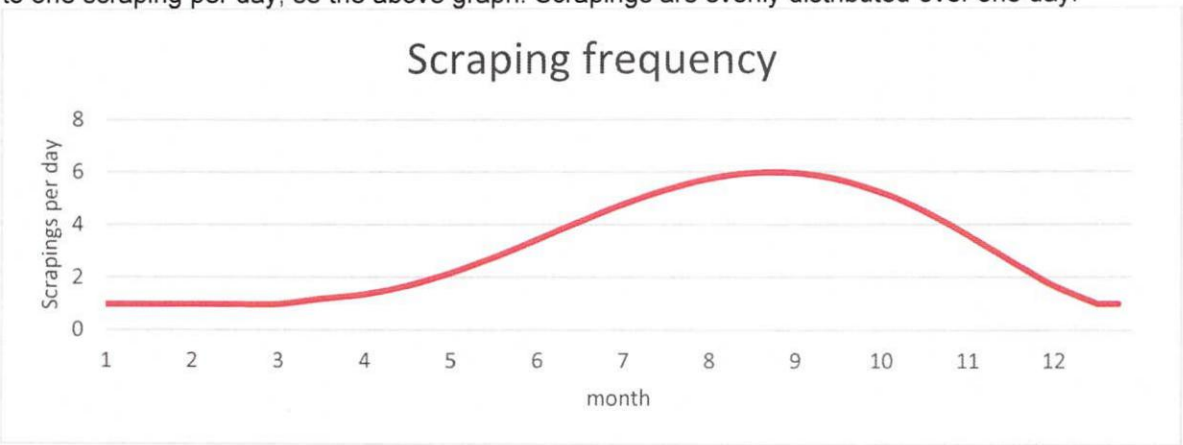

Figure 1 shows scraping frequency as a function of the time of the year. The algorithm can be explained as:
*y =if 12<x>3;(0,0143x5 - 0,4712x4 + 5,2004x3 - 22,138x2 + 36,326x)/78*6;1*
*x = month + ((1 / 10) * months) 1 month = approximately 30.42 days*

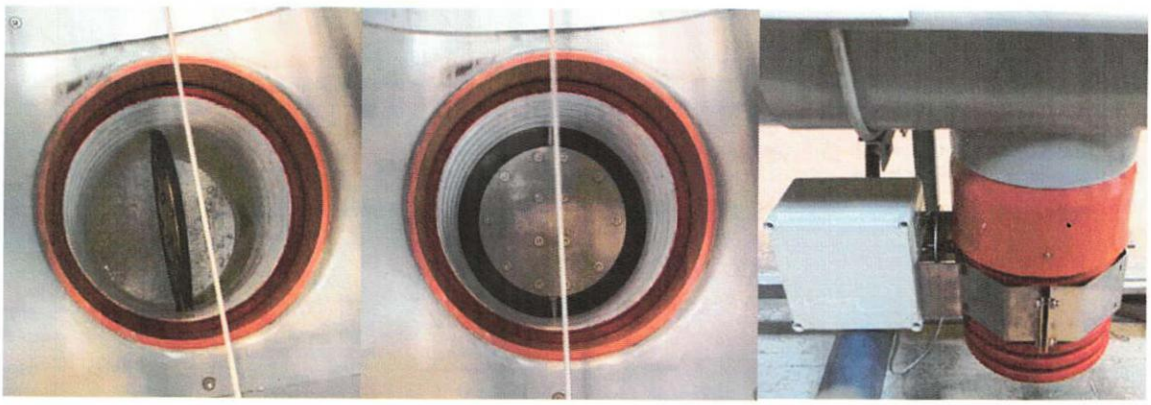

Figure 2: Valve in drain for automatic open and closure of slurry drain. The valve automatically opens 2 meters before the scraper flap meets the slurry drain and is otherwise closed all the time.

2 Application

The intended application of SmartScrape is described in terms of the matrix and the purpose.
The main purpose of the technology is to reduce ammonia, odor, and greenhouse gas emissions.

2.1. Matrix

The matrix is NH_3 and odour concentration in surrounding of mink farms

2.2. Purpose

The primary purpose is to verify the effect on ammonia and odor reduction using the SmartScrape system.

2.3. Conditions of operation and use

The specification of the test units can be seen in Table 1. The actual number and size of mink is reported for each measuring period together with the evaluation of the results.
The mink production can be described as traditional at both test farms. Mink offspring are born in the beginning of May and taken out of production (pelted) in November - December. In the period from December until May only adult females and males are required for mating and production the following year are housed.
The housing systems are naturally ventilated, and no external heating is introduced. The selection of test unit is done according to specific test requirement regarding identical ventilation, housing system and stocking rate.

2.4. Verification parameters definition summary

Odor and ammonia are the two-primary performance parameters. In addition, operational parameters were measured throughout the test period. A list of the parameters can be seen in tables 2 to4.

Parameter	Analytical method	Limit of detection	Uncertainty
Odour	Olfactometric analyses, EN 13725/AC:2003	11 OUE/m3	+161% / -62% Incl. sampling, analysis and delusion
NH3	PICARRO G2508 Gas Analyzer Reference: Impingers	0.14 mg/m3	<1 ppb +0.05% of reading

Table 1 Performance parameters, analytic methods, detection limits and uncertainty.

The verification involved measurements of the following operational parameters:

Parameter	Analytical method	Limit of detection	Uncertainty
Air Temperature	Testo 174H	0.1 °C	±0.5 °C (-20 to +70 °C)
Relative air humidity	Testo 174H	0.1 %	±3 %RH (2 to 98 %RH)
CO2	PICARRO G2508 Gas Analyzer Reference: GC-TCD	2.5 mg/m3	<200 ppb +0.05% of reading
Electricity consumption of tested technology	Calculated from electrical effect and on-time		
Number and weight of mink	Manually logged every period		

Table 2 Operational parameters, analytic methods, detection limits and uncertainty.

The verification involved measurements of the following environmentnal parameters:

Parameter	Analytical method	Limit of detection	Uncertainty
Wind • direction [°] • speed [m/s]	Davis vangate pro2	 0.1 m/s 1°	 ±5 % ±3 %

Table 3 Environmental parameters, analytic methods, detection limits and uncertainty

The user manual and implications on occupational health were not evaluated in this verification.

3. Test and analysis design

The test is designed to test how efficiently a new method of frequent removal of manure using the Smart-Scrape system can reduce odor and ammonia emissions from mink production. The test was performed based on the test requirement of the VERA test protocol for Livestock Housing and Management systems.

3.1. Existing and new test data

No data from previous tests have been used for calculation of the performance parameters. The verification is based solely on measurements done by the test institute in the test period specified.

3.2. Laboratory or field conditions

The mink production can be described as traditional at both test farms. Mink offspring are born in the beginning of May and taken out of production (pelted) in November - December. In the period from December until May only adult females and males are required for mating and production the following year are housed.

The test was conducted at two commercial mink farms. Both farms produce standard types of mink in a typical housing system for mink production. On each test site, one house was selected as test unit. The technology was tested after the on/off case control principle, where the technology is tested in the same house while switching on and off periodically. Most of the samplings did take place during summer and early autumn when temperatures were high, and the number and mass of mink were highest.
The housing systems are naturally ventilated, and no external heating is introduced.

The characteristics of the test units can be seen in Table 1. The farms were selected according to specific test requirements regarding identical ventilation and housing system, stocking rate
(Approximately same number of housed animals per m^2)

3.3. Matrix compositions

The matrix composition is the operation of the SmartScrape system which is developed for handling of mink slurry. Optimal performance of SmartScrape is achieved when the slurry level in the gutters is less than 1 cm. because this minimizes the surface area of uncovered liquid manure and thereby the ammonia emission.

3.4. Test and analysis parameters

Odor and ammonia are the primary measurement parameters, see table 4.

Parameter	Analytical method	Number of measuring periods	No. of samples/ measuring period	Sampling time/period
Odor	Olfactometric analyses, EN 13725/AC:2003	6 measuring periods	3	30 minutes
NH_3	PICARRO G2508 Reference: Impingers	6 measuring periods	Continuous measurements in situ.	Continuous

Table 4 Primary analytical parameters, analytical methods, number of samples and sample time.

Table 5 gives the conditional parameters, which may influence the emission level of the primary environmental pollutants. In addition, the table includes electrical consumption.

Parameter	Analytical method	No. of measuring periods	Sampling time/period
CO_2	PICARRO G2508 Gas Concentration Analyzer Reference: GC-TCD sampled in Tedlar bags	6	Continuous measurements in situ.
Temperature	Testo 174H	6	Continuous during sampling
Relative humidity	Testo 174H	6	Continuous during sampling
Electricity consumption of tested technology	Calculated	6	Logbook
Wind • direction [°] • speed [m/s]	Davis vangate pro2	6	Averages during sampling.

Table 5 Conditional parameters and corresponding analytical methods.

3.5. Tests and analysis methods summary

Odor

Odor samples was sampled and stored during transport according to the description given by the Danish EPA, Miljøstyrelsen (2006) regarding sampling and analyses of odor samples from livestock production units. Samples were sampled just before and under scraping for both technology and reference.

The odor samples from the mink houses were analyzed by olfactometric, where odor concentration is determined by dilution and odor panel evaluation by the internal odor analytic institute (DMRI-Taastrup) according to the standard EN 13725/AC:2003

Ammonia and CO_2

The ammonia and CO_2 concentration sampled inside and outside the mink production building was analyzed continuously using Cavity Ring-Down Spectroscopy (CRDS), PICARRO G2508 Analyzer specially optimized for ammonia. The analyzer collects data every second and changes measuring point every 5 minutes. Because of the response time for ammonia only the last minute for every 5 minutes was used for the emission calculations.

As standard reference method, Impinger system is used for validation of NH_3 concentration and parallel gas samples are analyzed by gas chromatography with a thermal conductivity detector (GC-TCD) for validation of CO_2 concentration.

From each sampling line 0,18 L/min. flow is drawn for a period of one minute, each hour equals to around 30 L every week. The air first passes two 400 ml impingers (12 mM H_2SO_4) and is then collected in a 30 L Tedlar bag for later analysis og CO_2. The flow was measured before and after every measuring period and the flow was checked by the volume of the Tedlar bag. Se measuring setup above. Ammonia sampled by the impingers were later analyzed with photo spectroscopy using the indophenol reaction.

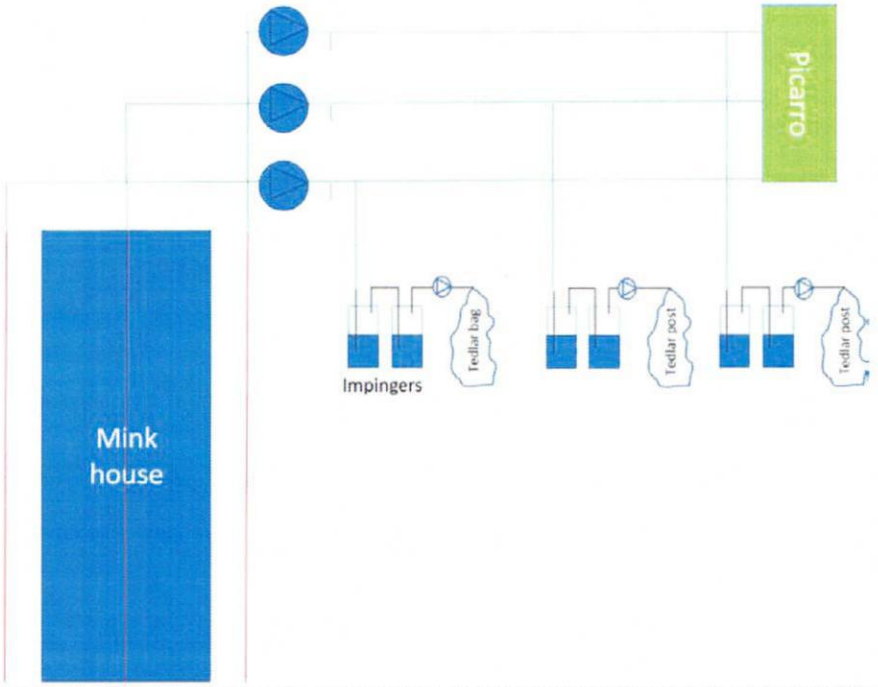

Figure 3 Measuring setup at a mink house where Picarro G2508 multigas analyzer is measuring along with parallel sampling for ammonia (impingers) and CO2 (Tedlar bag)

3.6. Parameters measured

NH_3, odour, CO_2, Temperature, Relative humidity, Electricity consumption, Wind direction and speed.

4. Verification results

The verification has been successfully performed and has found a significant reduction. The overall efficiency for ammonia is calculated as the average efficiency between the two locations and is found to be 37.3 %.
The mean emission for the reference was found to be 142.9 and 168.3 kg NH_3 $year^{-1}$ LU^{-1} and 100.7 and 94.4 kg NH_3 $year^{-1}$ LU^{-1} using SmartScrape at the farm locations in Barrit and Søndersø, respectively.

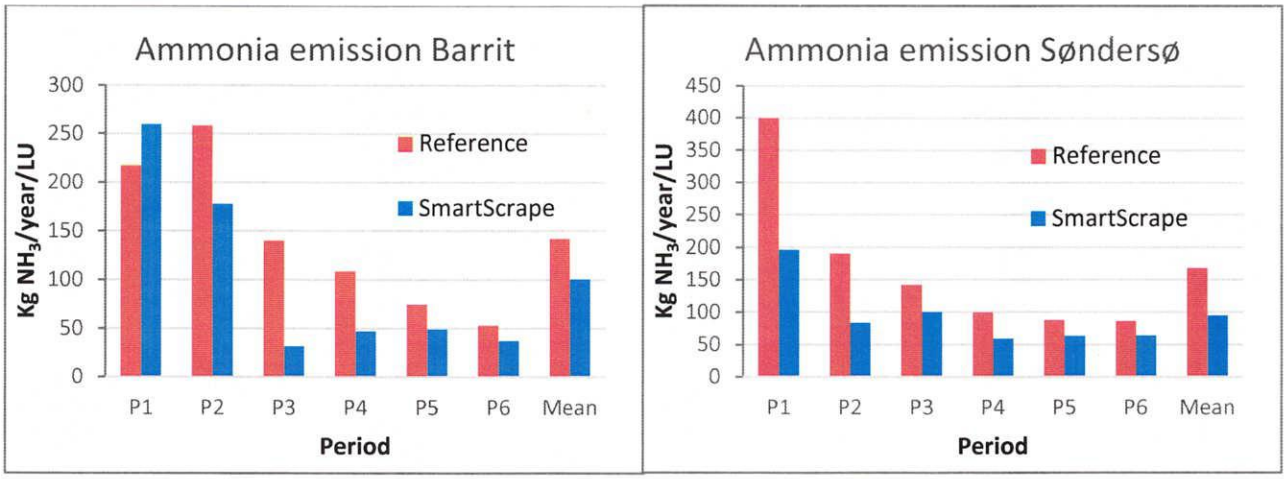

Figure 4 Ammonia emission from the two farms over the 6 periods.

The odor reduction was 37.5 % which was not significant.

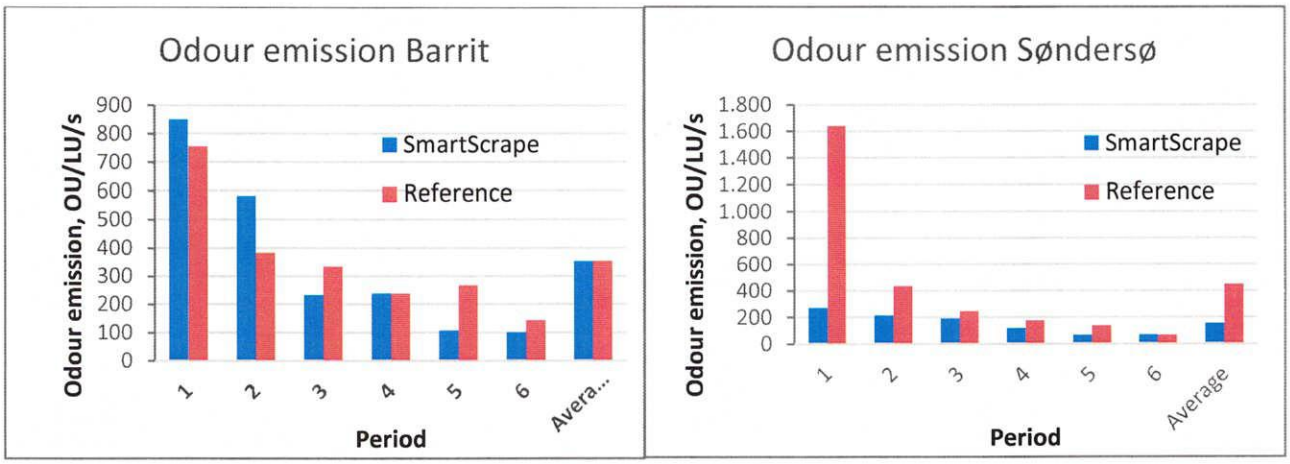

Figure 5 Odour emission from the two farms over the 6 periods

The SmartScrape system have shown stable operation without breakdowns during the test period.

Energy consumption was calculated to be 33 % lower than under normal operation.

5. Additional information, including additional parameters

No additional information or additional parameters has been identified during the test

6. Quality assurance and deviations

The quality of the analyses was controlled as described in the test report.

A test system audit was performed by ETA-Danmark during the tests on March 4th, 2020.

There have been 6 incidents where the farmer has manual overridden the system and activated the scraping in a reference period. In the operation log, a full list of all actions is described.
Data was removed 4 times due to unauthorized scraping in a reference period. These incidents were evaluated to have small effect of the result because there is 4 days close to reference conditions. It will however have negative effect on the measured effect of the technology because 1/3 of the reference conditions is closer to 2 scrapings per week than 1.
In one measuring campaign the data quality was very poor due to system failure. This resulted in a quite short measuring period, but it led to a non-significant effect. One measuring period was generally a bit squeezed because it needed to be finished before the mink was taken out of the building. This is evaluated not to have a significant effect on the results.
Five odor analyses were removed from the dataset as outliers because the values were > Q3+3*IQR.