SyreN
Reduced emissions following land application of animal slurry

Verification report

Document information

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1 TABLE OF CONTENTS

2 INTRODUCTION

Environmental technology verification (ETV) is an independent (third party) assessment of the performance of a technology or a product for a specified application, under defined conditions and quality assurance.

This document is the verification report resulting from the test and verification of a specific product, SyreN, used for reducing emissions following land application of slurry.

2.1 Name of product

The product verified was SyreN slurry land application system.

2.2 Name and contact of vendor

SyreN is developed by BioCover A/S, Veerst Skovvej 6, Veerst, DK-6600 Vejen, Denmark. Website: www.biocover.dk. Contact person of BioCover is Morten Toft. Email: morten.toft@mail.dk. Phone: +45 2963 4936.

2.3 Name of center and verification responsible

Verification centre: DANETV, Test Centre AgroTech, Agro Food Park 15, DK-8200 Aarhus N, Denmark.

Verification responsible: Thorkild Q Frandsen, AgroTech, Agro Food Park 15, DK-8200 Aarhus N, Denmark. Phone: +45 8743 8468, e-mail: tqf@agrotech.dk.

2.4 Verification and test organization

The verification was conducted by Danish Centre for Verification of Climate and Environmental Technologies, DANETV, which performs independent tests of technologies and products for reduction of climate changes and pollution.

The verification was planned and conducted to satisfy the requirements of the ETV scheme currently being established by the European Union (EU ETV).

An internal and an external technical expert have provided independent review of the planning, conducting and reporting of the verification and test.

An overview of the organisation associated with test and verification is given in figure 1.

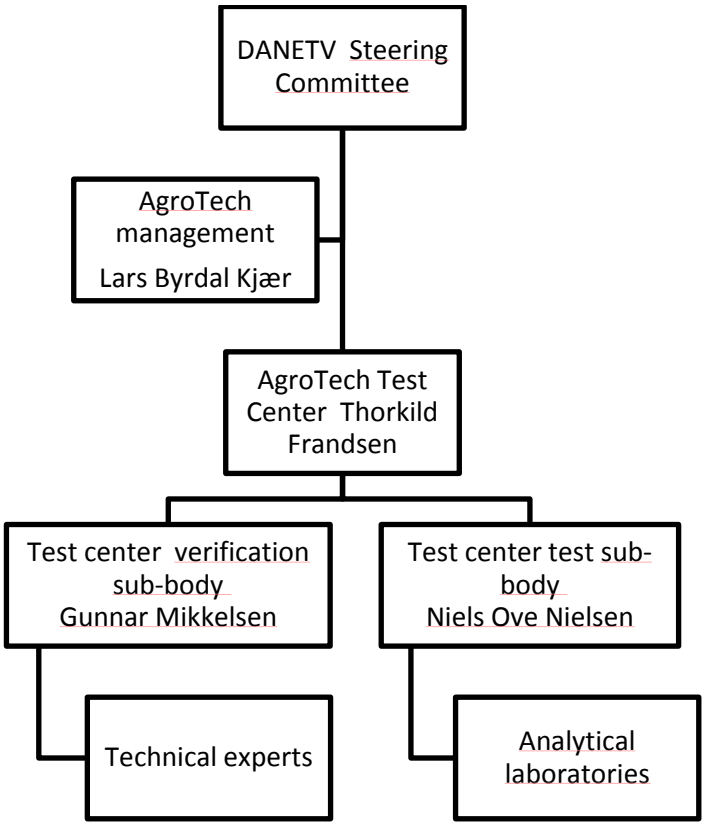

Figure 1. Organisation of test and verification.

2.5 Expert group

The technical experts assigned to this verification and responsible for review of the verification protocol and report documents include:

External expert: Tavs Nyord, Aarhus University, Faculty of Science and Technology, Blichers Allé 20, PO Box 50, 8830 Tjele, Denmark. Phone +4587157637. E-mail: tavs.nyord@agrsci.dk

Internal expert: Torkild Birkmose, AgroTech, Agro Food Park 15, DK-8200 Aarhus N, phone: +45 3092 1707, e-mail: TSB@agrotech.dk.

2.6 Verification process

Verification and tests were conducted in two steps, as required by EU ETV. The steps in the verification are shown in Figure 2.

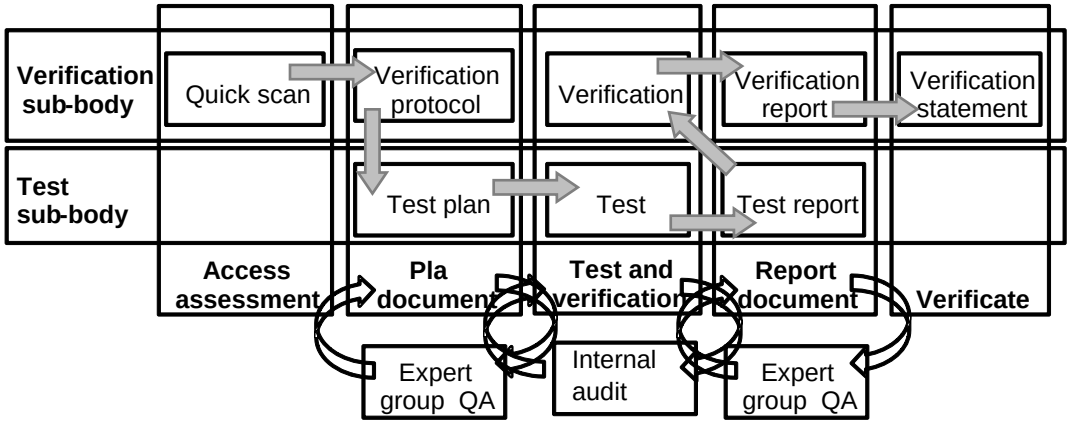

Figure 1. Verification steps.

The verification process is described in the AgroTech Test Centre Quality Manual [1].

The verification protocol, the test plan and the AgroTech Test Centre Quality Manual shall be seen as one consolidated verification description.

3 DESCRIPTION OF THE TECHNOLOGY

In most European countries the major part of the manure from large livestock housing systems is handled as liquid manure, slurry. Slurry is a mixture of faeces and urine including normally also some bedding material and some water from management.

Usually, slurry is taken from the livestock housing systems and collected in large storage tanks throughout the year and used as organic fertilizer on the fields close to the farm during the growing season of the crops.

A wide range of technologies can be used for applying slurry to the fields. During the last 10-20 years efforts have been made to develop technologies resulting in reduced gaseous emissions following land application of slurry. Focus is on reducing ammonia emission and odor emission. Reduced ammonia emissions can lead to both a better utilisation the nitrogen which is an important nutrient for the crops and at the same time the negative impact on environment due to eutrophication is reduced. Reduced odor emission benefits the people living in the country side due to reduced odor nuisance in those periods when slurry is spread on the fields.

4 DESCRIPTION OF THE PRODUCT

The basic idea of the SyreN slurry application system is to add sulphuric acid and/or iron sulphate to animal slurry during land application. In a liquid ammonium will be in equilibrium with ammonia in its aqueous and gaseous forms as follows: NH_4^+ (aq) <—> NH_3 (aq) <—> NH_3 (gas). If pH is reduced the equilibrium is displaced to the left. By adding sulphuric acid to slurry pH is decreased and ammonia emission is reduced.

When iron sulphate is added to slurry Fe^{3+} will be reduced to Fe^{2+} which reacts with sulfide (S^{2-}) under formation of iron sulfide with a low solubility in water. Sulfide is one of the main contributors to odour from slurry. Therefore, addition of Fe^{3+} and the resulting precipitation of iron sulfide can lead to reduced odour emission from slurry application.

SyreN is an add-on system to be installed on existing slurry application machinery, which normally consisting of a tractor and a slurry tanker. There are three main parts of the SyreN system:

1. Front tanks for storage of sulphuric acid and iron sulphate during land application
2. Terminal software for regulation of dosage of sulphuric acid and iron sulphate to slurry tanker
3. Pumps for addition of sulphuric acid and iron sulphate to slurry tanker.

Figure 3 shows a photo of the SyreN system installed on a tractor with a slurry tanker.

Figure 3. The SyreN-system includes three tanks installed on the front of the tractor. 1: Tank for iron sulphate. 2: Here the tank for sulphuric acid shall be placed. 3: Tank for water for cleaning the system.

Table 1 gives an overview of the main parts of the SyreN system.

Table 1. Overview of the main parts of the SyreN system.

System part	Purpose
Front tanks	Storage system for sulphuric acid and Fe^{3+} during land application
Terminal software	Regulation of dosage of sulphuric acid and Fe^{3+} to slurry tanker
Pumps	Addition of sulphuric acid and Fe^{3+} to slurry tanker
Slurry tanker	Transport and land application of acidified animal slurry

5 APPLICATION AND PERFORMANCE PARAMETERS

The intended application of the SyreN is defined in terms of the matrix, the target and the effect of the land application system.

The matrix is the type of material that the system is intended for. Targets are the measurable properties that are affected by the SyreN system. The effects describe how the targets are affected by the SyreN system.

A detailed description of the application is presented in Appendix 3 – Application and performance parameter definitions.

5.1 Matrix

The SyreN system was verified for the following matrices:

- Cattle slurry applied to grass land
- Pig slurry applied to winter wheat

5.2 Targets

For the SyreN slurry application system the targets of the application are:

- Odour concentration from cattle slurry applied to grass land
- Ammonia emission from cattle slurry applied to grass land and pig slurry applied to winter wheat

5.3 Effects

For the SyreN system the effects of the application are:

- Reduced odour concentration following application of cattle slurry using the SyreN system with addition of iron sulphate compared to application of cattle slurry using standard slurry application systems (trailing hoses).
- Reduced ammonia emission using the SyreN system with addition of sulphuric acid for application of cattle slurry to grass land compared to standard slurry application equipment (trailing hoses).
- Reduced ammonia emission using the SyreN system with addition of sulphuric acid for application of pig slurry to winter wheat compared to standard slurry application equipment (trailing hoses).

5.4 Performance parameters for verification

The performance parameters provide the relevant information on the performance of the technology product. In the case of SyreN slurry application system the performance parameters are:

- Odour concentration in air sampled above land where slurry was applied (odour units (OU_E) m^{-3} air)
- Loss of NH_3-N in percent of applied NH_4-N

The claims put forward by the company, which has developed the SyreN system (Bio-Cover) are described in table 2 below.

Table 2. Performance claims for the SyreN system put forward by BioCover.

Performance parameter	Application	Claim
Odour concentration	Reduction from land application of cattle slurry to grass land using the SyreN system with addition of iron sulphate compared to application with standard equipment (trailing hoses).	40 %
Ammonia emission	Reduction from land application of pig slurry to winter wheat using SyreN system with addition of sulphuric acid compared to application with standard equipment (trailing hoses).	30 %
Ammonia emission	Reduction from land application of cattle slurry to grass land using SyreN system with addition of sulphuric acid compared to application with standard equipment (trailing hoses).	30 %

5.5 Additional parameters

Additional parameters are effects of the product that were described as part of the verification but are considered secondary compared to the primary performance parameters.

5.5.1 Operational parameters

As part of the verification of SyreN´s effect on ammonia emission the following operational parameters were evaluated:

- Amount of sulphuric acid used
- pH in slurry

As part of the verification of SyreN´s effect on odour emission the following operational parameter was evaluated:

- Amount of iron sulphate used (liter/ton slurry applied).

5.5.2 Occupational health and safety

Occupational health and safety issues were not evaluated as part of the verification.

In general all industrial machinery and equipment – must comply with the Machinery Directive 89/392/EEC (Amended 98/37/EEC). They must be designed and constructed in such a way that they can be used, adjusted and maintained throughout all phases of their life without putting persons at risk.

5.5.3 User manual

No evaluation of the user manual for the SyreN slurry application system was done as part of this verification.

6 EXISTING DATA

A number of tests have been performed demonstrating the effect of lowering the pH value in slurry on ammonia emission.

6.1 Summary of existing data

No independent tests have previously been performed on the SyreN slurry application system.

6.2 Quality of existing data

No previous tests of the SyreN system have been undertaken by independent test bodies. Furthermore, data from previous tests are not representative for the final product.

6.3 Accepted existing data

No data from previous tests have been included in this verification of the SyreN slurry application system.

7 TEST PLAN REQUIREMENTS

Based on the application and performance parameter identification above the requirements for the test design have been set. A detailed test plan was prepared by the test organisation based upon the specification of the test requirements presented below.

7.1 Test design

All tests of environmental technologies were performed according to the selected environmental parameters, ammonia and odour as described below. All tests were performed as case-control (reference) studies.

7.1.1 Requirements for the test site

For this verification the requirements defined in the VERA Test Protocol for Measurement of Gaseous Emissions from Land Applied Manure were used. See [2]. In table 3 below the requirements for the test site are described.

Table 3. Requirements for test site parameters.

Parameter	Requirement
Size of experimental plots	Circular plots having a radius of minimum 20 m in case of ammonia and more than 2,5 m^2 in case of odour.
Number of experimental plots	Minimum 3 experimental plots are required for both the environmental technology and the reference technology. The test can favourably be carried out at separate times of the year, meeting that way variance in weather and field conditions.
Sampling period of year	Periods in spring to autumn (5-15°C). Tests should not be performed if precipitation is expected within six hours after manure application.
Definition of crop	Type and height of crop (or bare soil) in the experimental plots have to be described.
Definition of soil	The type and humidity of soil in the experimental plots have to be defined.

7.1.2 Sampling strategy

The sampling strategy for this verification follows the requirements described in the VERA Test Protocol for Measurement of Gaseous Emissions from Land Applied Manure. An overview of the requirements is given in table 4.

Table 4. Overview of requirements for sampling strategy.

Parameter	Requirement
Number of sampling units	Ammonia: IHF method: 5 NH3 traps per experimental plot Zinst method: 2 NH3 traps per experimental plot Odour: 3 sampling units per experimental plot, minimum 1 odour sampling per sampling unit
Length of sampling periods	Ammonia 6 days or more for solid manure types 4 days or more for liquid manure types Odour 20-30 minutes. The sampling has to be initiated 20 minutes after application of the manure
Composition of slurry	Two samples per load of applied manure per plot, if the slurry previously has been stirred and homogenized. Else, two samples per load of applied slurry per plot, where each sample has to consist of ten representatively taken subsamples.

The emission of ammonia from the animal slurry applied to agricultural land by the SyreN technology was quantified by a test design based on the micrometeorological mass balance technique. The technique is described in detail by Denmead (1983), Ryden et al. (1984), Leuning *et al.* (1985); Sherlock *et al.* (1989), Huijsmans et al. (2001), but will be described briefly below.

The micrometeorological mass balance technique involves a measuring mast situated centrally in each experimental plot, and a background measuring mast located outside the plots for measurement of the background NH_3 levels. Figure 2 is an illustration of the test setup used for the micrometeorological mass balance technique.

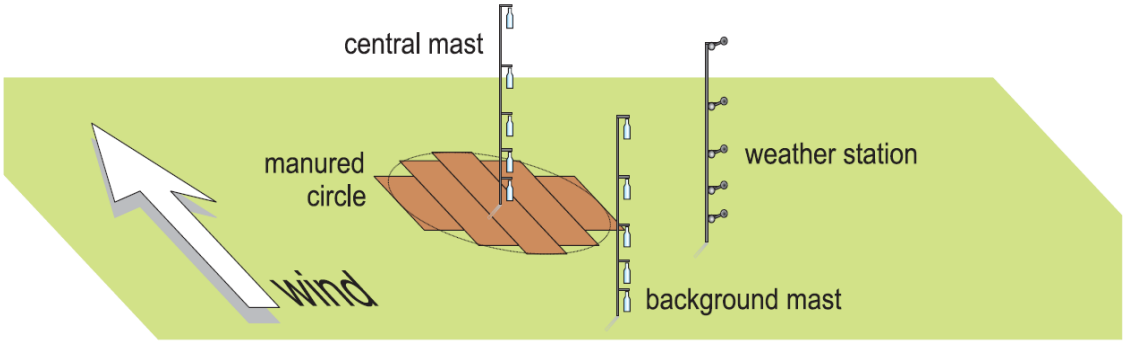

Figure 4. Layout of a circular plot for the measurement of NH3 volatilization using the micrometeorological mass balance method, with masts supporting NH3 traps at various heights in the center of the plot and at the windward boundary of the plot. Source: VERA Secretariat, 2009 [2].

The data obtained by this protocol are highly depending on the weather and field conditions during land application and sampling. Table 5 includes an overview of weather and field conditions to be measured as part of the test activities.

Table 5. Overview of weather and fields conditions to be measured as part of the test activities.

Weather and field conditions	Unit
Application time	Time of the day, and month
Wind speed (2 m)	M s^{-1}
Wind direction	
Atmospheric humidity (2 m)	RH (%)
Radiation	W m^{-2}
Air temperature (2 m)	˚C
Soil temperature (10 cm)	˚C
Soil type	Content of clay, silt, and sand
Soil moisture	G kg^{-1} soil
Precipitation	mm

7.2 Reference analysis

All measurements and analytical methods had to be documented satisfactory. No specific reference analysis was performed for this verification.

7.3 Data management

Data storage, transfer and control was done in accordance with the requirements described in the AgroTech Test Centre Quality Manual. Similarly, filing and archiving requirements are described in the AgroTech Test Centre Quality Manual.

7.4 Quality assurance

The test plan and test report were reviewed by an internal and an external expert.

7.5 Test report

The test report was based on the template included in the AgroTech Test Centre Quality Manual.

8 EVALUATION

8.1 Calculation of performance parameters

The ammonia emission effect of the SyreN system was tested in four comparative studies of ammonia emission following trailing hose application of animal slurry (reference), and trailing hose application of animal slurry added between 1.9 and 2.9 l of sulphuric acid (96 %) per 1000 l of applied slurry (SyreN). The ammonia emission from land applied animal slurry was on average found to be reduced by 42 per cent when the pH of the slurry was reduced by addition of between 1.9 and 2.9 l of sulphuric acid per 1000 l of animal slurry by the SyreN application system.

The odour effect of the SyreN system was tested in two comparative studies of the odour concentration in air sampled above trailing hose applied cattle slurry (reference), and trailing hose applied cattle slurry added between 2.3 and 2.9 l of sulphuric acid (96 %) per 1000 l of applied slurry (SyreN), and one comparative study of the odour effect of addition of 0.5l of Fe^{3+} sulfate (42%) per 1000 l of cattle slurry. It was found that the odour concentration right after land application was unaffected by the addition of sulphuric acids, while the odour concentration was lower in air sampled above land applied cattle slurry added Fe^{3+} than in air sampled above land applied untreated cattle slurry. The long term odour effect of addition of sulphuric acids and Fe^{3+} to animal slurry, and the odour effect of both addition of sulphuric acid and Fe^{3+} to animal slurry were not studied.

The emission of ammonia was measured both for pig slurry land applied to winter wheat and for cattle slurry land applied to grass land. The emission from animal slurry applied by the SyreN system was compared to the emission of untreated slurry applied by trailing hoses and by shallow injection.

Trailing hose application of slurry was found to give the highest emission of ammonia, while shallow injection of animal slurry was found to give the lowest emission (Table 6). The ammonia emission from trailing hose applied animal slurry added between 1.9 and 2.9 l of sulphuric acid by the SyreN system was found to be 42 per cent lower on average than the ammonia emission from trailing hose applied untreated animal slurry.

Table 6. Average ammonia (NH_3) emission from pig and cattle slurry following land application by trailing hoses, shallow injection and the SyreN system. The SyreN system was trailing hose application of animal slurry added between 1.9 and 2.9 l of sulphuric acid per 1000 l of slurry.

Type of slurry	Crop	NH_3-N loss, % of applied NH_4-N		
		Trailing hoses	Shallow injected	SyreN
Pig slurry	Winter wheat	23	11	15
Cattle slurry	Grass land	41	18	21

The odour nuisance of animal slurry following land application was measured by olfactometric analyses. The effect of the SyreN application system was only tested for application of cattle slurry to grass land. The odour effect of both addition of sulphuric acid (acid) and iron sulfate (Fe^{3+}) was tested, but not together. The odour effect was compared to trailing hose application, and shallow injection of untreated cattle slurry. As the test of Fe^{3+} failed the first measuring day, this test was repeated twice the second measuring day (table 7).

Table 7. Average odour concentration measured in air sampled above cattle slurry land applied by trailing hoses, shallow injection and by the SyreN system with addition of sulphuric acid or iron sulphate (Fe^{3+}). The SyreN system was trailing hose application of animal slurry added between 1.9 and 2.9 l of sulphuric acid per 1000 l of slurry or 0.5 l of Fe^{3+} per 1000 l of animal slurry. Values shown in parentheses are standard error of means.

Measuring day	***Odour concentration, Odour units (OU_E) m^{-3} air***				
	Trailing hoses	Shallow inject-ed	SyreN acid	SyreN Fe^{3+} a	SyreN Fe^{3+} b
1: 02.06.2010	903 (225)	320 (60)	853 (132)	-*	-*
2: 15.06.2010	627 (90)	310 (32)	737 (203)	363 (67)	320 (51)

* As the test of addition Fe^{3+} failed the first measuring day, this test was repeated twice the second measuring day.

It was found that the odour concentration right after trailing hose application was unaffected or slightly increased by addition of sulphuric acids to the slurry by the SyreN system, while the odour concentration was lower in air sampled above land applied cattle slurry added Fe^{3+} than in air sampled above trailing hose applied untreated cattle slurry (Figure 5). Higher concentrations of odour were found above trailing hose applied slurry added sulphuric acid than in air sampled above shallow injected slurry. The long term odour effect of addition of sulphuric acids and Fe^{3+} to animal slurry, and the odour effect of both addition of sulphuric acid and Fe^{3+} to animal slurry were not studied in this test.

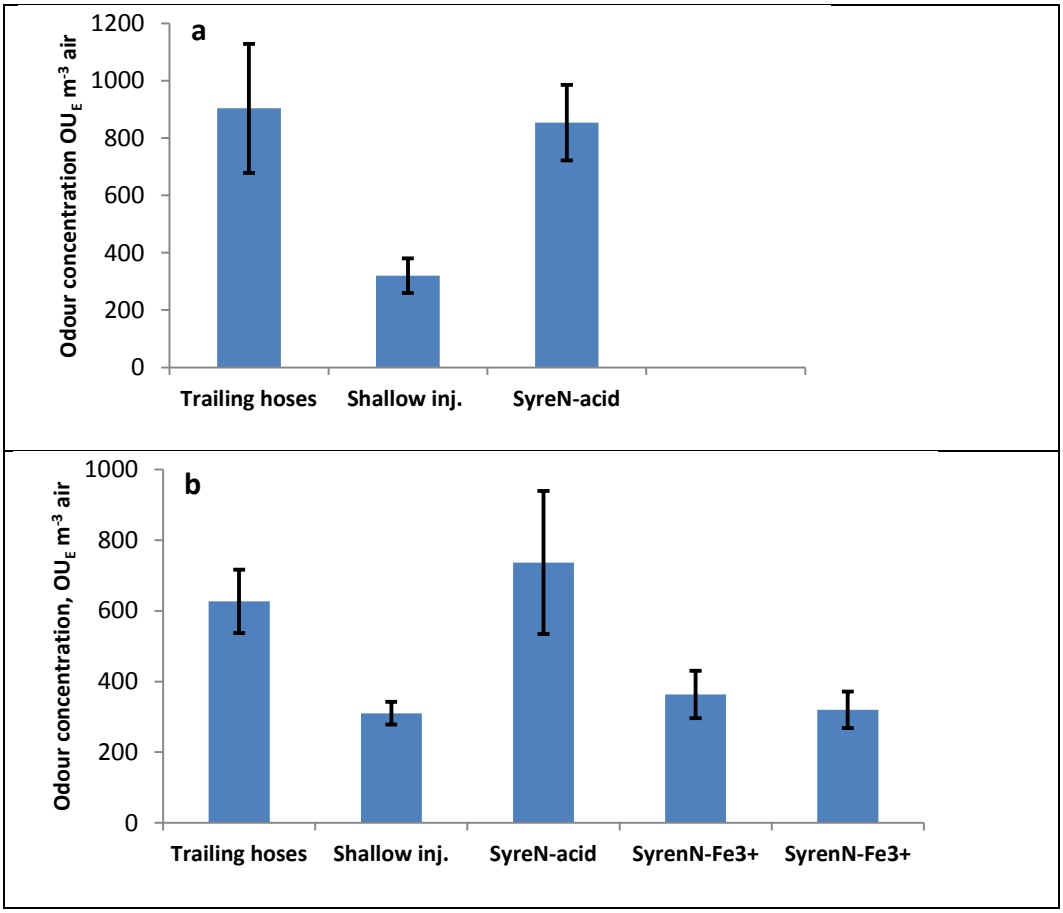

Figure 5. Odour concentration in air sampled above land applied cattle slurry. The cattle slurry was applied to grassland by trailing hoses, shallow injection, or by addition of sulphuric acid (SyreN-acid), or addition of iron sulphate (Fe^{3+}) by use of the SyreN system (SyreN-Fe^{3+}). The top diagram (a) shows the results obtained following land application the 2. of June, and the diagram b shows the results obtained the 15. of June. All data were sampled seven minutes after land application. Error bars show the standard error of means.

8.2 Performance parameter summary

In table 8 below the verified performance is compared with the performance claimed by the technology producer, BioCover.

Table 8. Verified performance compared with claimed performance.

Performance parameter	Application	Claimed performance	Verified performance
Odour concentration	Reduction from land application of cattle slurry to grass land using the SyreN system with addition of iron sulphate compared to application with standard equipment (trailing hoses).	40 %	46 %
Ammonia emission	Reduction from land application of pig slurry to winter wheat using SyreN system with addition of sulphuric acid compared to application with standard equipment (trailing hoses).	30 %	35 %
Ammonia emission	Reduction from land application of cattle slurry to grass land using SyreN system with addition of sulphuric acid compared to application with standard equipment (trailing hoses).	30 %	49 %

8.3 Evaluation of test quality

The ammonia emission effect of the SyreN system was tested in minimum three independent tests following land application of pig slurry and minimum three independent test following land application of cattle slurry.

The odour effects of the SyreN land application system were tested in two independent test following land application of cattle slurry to grassland. All samplings and analyses in these tests were triplicated.

8.3.1 Control data

To verify the effect of adding sulphuric acid to the slurry pH of untreated and treated slurry was measured. The results of pH-measurements can be seen in table 9 below.

8.3.2 Audits

No external or internal audits were undertaken for this specific verification task.

8.3.3 Deviations

It was part of the test plan to include measurements on the effect on odour emission from addition of both sulphuric acid and iron sulphate in order to evaluate the effect from this combination. Due to technical problems related to the SyreN system no sulphuric acid was added during the test. Consequently this report includes results from addition of iron sulphate without addition of sulphuric acid at the same time.

Unfortunately the addition of Fe^{3+} to the slurry failed during the test on the first measuring day (02.06.2010) due to technical problems related to the SyreN system. Consequently, there are no odour concentration results from this first measuring day. Instead this test was done twice on the second measuring day (15.06.2010).

8.4 Additional parameter summary

8.4.1 User manual

No evaluation of the user manual for the SyreN slurry application system was done as part of this verification.

8.4.2 Occupational health and wastes

Occupational health and safety issues were not evaluated as part of the verification.

8.5 Operational parameters

The amount of sulphuric acid used was measured together with the pH of untreated and acidified slurry. The results are presented in table 9.

Table 9. Amount of sulphuric acid used by the SyreN system and the resulting pH in the acidified slurry in the ammonia study.

Day of experiment	Type of slurry	Type of crop	Supplied acid l t^{-1} slurry	pH of slurry	
				Untreated	Acidified
04.05.2010	Pig slurry	Winter wheat	2.0	7.2	6.1
18.05.2010	Pig slurry	Winter wheat	2.2	7.9	6.7
02.06.2010	Cattle slurry	Grass	2.3	7.4	6.1
15.06.2010	Cattle slurry	Grass	2.9	7.8	6.5

In table 9 it is seen that for pig slurry in average 2.1 litre of sulphuric acid per ton slurry were added by the SyreN system. For cattle slurry 2.6 litre per ton slurry were used in average.

In the odour emission test an amount of 0.5 litre of iron sulphate per ton slurry was added to the cattle slurry by the SyreN system.

8.6 Recommendations for verification statement

It is recommended to issue a verification statement based on the verified performance described in section 8.1, 8.2, 8.3 and 8.5.

8.7 Liability exclusion

DANETV verifications are based on test and evaluation of technology performance under specific, predetermined operational conditions and parameters and the appropriate quality assurance procedures. AgroTech makes no expressed or implied warranties as to the performance of the technology and do not certify that the technology will always operate as verified. The end user is solely responsible for complying with any applicable regulatory requirements.

9 VERIFICATION SCHEDULE

The test activities related to this verification were planned and carried out in 2010. The verification report and verification statement were finalised in 2012. The overall schedule is presented in table 10.

Table 10. Schedule for verification of SyreN slurry application system.

Task	Timing
Quick scan and contract negotiation	April – May 2010
Verification protocol and test plan	April – May 2010
Test activities and results of analyses ready	May – October 2010
Test reporting	August 2010 – December 2011
Verification report	January 2012 – March 2012
Report document review	December 2011
Verification statement	March 2012

10 QUALITY ASSURANCE

The quality assurance of the verification is described in table 11 below and in figure 2. The quality assurance of the test is described in the test plan.

Table 11. Quality assurance plan for the verification of SyreN slurry application system.

Task	Internal expert	Technical expert
Plan document including verification protocol and test plan	Torkild Birkmose	Tavs Nyord, Aarhus University
Report document including test report and verification reports	Torkild Birkmose	Tavs Nyord, Aarhus University

Internal review of verification protocol, verification report, test plan and test report was done by Torkild Birkmose. No test system audit is planned for this verification task.

A P P E N D I X 1

Terms and definitions used in the verification report

Word	DANETV
Analytical laboratory	Independent analytical laboratory used to analyse test samples
Application	The use of a product specified with respect to matrix, target, effect and limitations
DANETV	Danish center for verification of environmental technologies
(DANETV) test center	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body
Effect	The way the target is affected
(Environmental) product	Ready to market or prototype stage product, process, system or service based upon an environmental technology
Environmental technology	The practical application of knowledge in the environmental area
Evaluation	Evaluation of test data for a technology product for performance and data quality
Experts	Independent persons qualified on a technology in verification
Matrix	The type of material that the product is intended for
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product
Procedure	Detailed description of the use of a standard or a method within one body
Producer	The party producing the product
Slurry	Faeces and urine produced by housed livestock, usually mixed with some bedding material and some water during management to give a liquid manure with a dry matter content in the range from about 1 – 10%. A slurry is a mixture of liquid and solid materials, where typically the solid materials are not dissolved in the liquid phase, and will precipitate out of the slurry under a prolonged period of storage.
Slurry additive	Manufactured or naturally occurring products or substances that are added to manures to modify their biological, chemical or physical properties. Many additives are commercially available but most have not been sub-

Word	DANETV
	jected to independent testing so their effectiveness has not been assessed.
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis
Target	The property that is affected by the product
Test center, test sub-body	Sub-body of the test centre that plans and performs test
Test center, verification sub-body	Sub-body of the test center that plans and performs the verification
Test/testing	Determination of the performance of a product for parameters defined for the application
Vendor	The party delivering the product to the customer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance

A P P E N D I X 2

References

[1] AgroTech (2009): AgroTech Test Centre Quality Manual. Not published.

[2] VERA Secretariat (2009): Test Protocol for Measurement of Gaseus Emissions from Land Applied Manure. Published by the Secretariat for Verification of Environmental Technologies for Agricultural Production (VERA). Available from www.veracert.dk. 28 pp.

[3] CEN (2003): Air Quality – Determination of Odour Concentration by Dynamic Ofactometry. EN 13725:2003. Published by European Committee for Standardization, Brussels, Belgium.

[4] Nyord, T., Adamsen, A.P., Liu, D., Petersen, S.O. og Hansen, M.N. (udateret): Emission af ammoniak, lugt og lattergas ved udbringning af gylle med slæbeslanger, nedfældning og forsuring med SyreN- og Infarmsystemer. Notat om SyreN-projekt. Not published. 18 pp.

[5] Miljøstyrelsen (2006): Bekendtgørelse om husdyrbrug og erhvervsmæssigt dyrehold, husdyrgødning, ensilage m.v. Bekendtgørelse nr. 1695 (19.12.2006).

A P P E N D I X 3

Application and performance parameter definitions

Applications

The intended application of the SyreN technology is defined in terms of the matrix, the target and the effect of the slurry land application system.

Matrix	The SyreN system was verified for the following matrices: • Cattle slurry applied to grass land • Pig slurry applied to winter wheat
Targets	For the SyreN slurry application system the targets of the applications are: • Odour concentration from cattle slurry applied to grass land • Ammonia emission from cattle slurry applied to grass land and pig slurry applied to winter wheat
Effects	• Reduced odour concentration following application of cattle slurry using the SyreN system with addition of iron sulphate compared to standard slurry application systems (trailing hoses). • Reduced ammonia emission following application of cattle slurry using the SyreN system with addition of sulphuric acid compared to standard slurry application equipment (trailing hoses). • Reduced ammonia emission following application of pig slurry to winter wheat using the SyreN system with addition of sulphuric acid compared to standard slurry application equipment (trailing hoses).
Exclusions	• The long term odour effect of addition of sulphuric acid and iron sulphate was not studied as part of this verification. • The effect on odour emission by addition of both sulphuric acid and iron sulphate at the same time was not studied as part of this verification. Only the effect of adding either sulphuric acid or iron sulphate has been studied.

General performance requirements

According to the Danish regulative requirements as a main rule slurry has to be applied to land using trailing hoses. However, in some cases the Danish rules [5] require that slurry land application technologies with lower emissions are used:

- On grass land and on black soil slurry has to be injected into the soil. However, other land application technologies can be used if they lead to a reduction in ammonia emission equal to or higher than slurry injection.

The consequence of these regulative requirements is that if SyreN system reduces the ammonia emission at least 25 % compared to application by trailing hoses, then the farmer can avoid using injection technology on grass land and on black soil.

Performance parameter definitions

The performance parameters are defined in section 5.4 above.

A P P E N D I X 4

Test report

The test report is attached to this verification report as a separate file.

A P P E N D I X 5

Review reports

Comments, questions, and proposals for improvements of plan documents and report documents have been communicated from internal and external reviewers both by email and by telephone and at meetings.

These comments, questions and proposals for improvements are stored according to the archiving procedures described in the AgroTech Test Centre Quality Manual.

A P P E N D I X 6

Amendment and deviation report for verification

Deviations
It was part of the test plan to include measurements on the effect on odour emission from addition of both sulphuric acid and iron sulphate in order to evaluate the effect from this combination. Due to technical problems related to the SyreN system no sulphuric acid was added during the test. Consequently this report includes results from addition of iron sulphate without addition of sulphuric acid at the same time.

Unfortunately the addition of Fe^{3+} to the slurry failed during the test on the first measuring day (02.06.2010) due to technical problems related to the SyreN system. Consequently, there are no odour concentration results from this first measuring day. Instead this test was done twice on the second measuring day (15.06.2010).

Amendments
The SyreN system´s effect on odour emission was evaluated by olfactometric analyses. However, during the test the olfactometric odour analyses were supplemented by continuously measurements of concentrations of key odour components in air above the slurry surface. These measurements were done by test staff of Aarhus University and the results are not included in this test report. However, the additional measurements are shortly mentioned in the following.

The investigations of key odour components showed a dynamic development in concentrations of specific odour components in air sampled above the slurry treated area.

This indicates that the odour concentration measured by the olfactometric analyses is depending on when the odour samplings were taken – the lag time between slurry application and odour sampling. The time lag chosen between slurry application and odour sampling may therefore influence the odour effect of the tested technology.

The odour test may therefore be improved by supplementation of test of the development of specific odour components and by repeated odour samplings following slurry application.