Jørgen Hyldgård Staldservice A/S

JH-FORSURING NH4+

Verification Protocol

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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 protocol to be used for verification of a technology for acidification of slurry in cattle housing systems.

2.1 Name of product

The product to be verified is JH-Forsuring NH4+.

2.2 Name and contact of vendor

JH-Forsuring is developed by the company Jørgen Hyldgaard Staldservice A/S, Nørgårdsvej 18, 7500 Holstebro, Denmark. Contact person of Jørgen Hyldgaard Staldservice is Ken Hyldgård. Phone: +45 97 42 81 89. E-mail: info@jhstaldservice.dk

The JH-FORSURING NH4+ is marketed and sold in Denmark by Jørgen Hyldgaard Staldservice A/S.

2.3 Name of centre and verification responsible

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

Verification responsible: Amparo Cortina. Phone: +45 8743 8470. E-mail: aco@agrotech.dk.

2.4 Verification and test organization

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

The verification is planned and conducted to satisfy the requirements of the ETV scheme which is under preparation by the European Union (EU ETV).

An internal and an external technical expert provide independent review of the planning, conducting and reporting of the verification and tests.

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

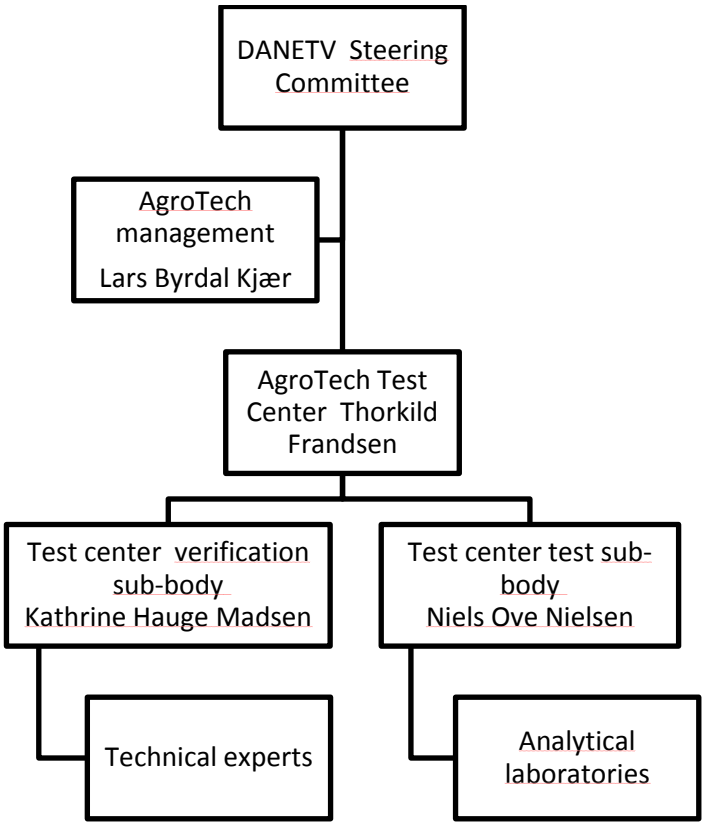

Figure 1. Organisation of test and verification

2.5 Expert group

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

Internal experts:
Thorkild Qvist Frandsen, AgroTech, Agro Food Park 15, DK-8200 Aarhus N. Phone: +45 8743 8468 E-mail: tqf@agrotech.dk.

Martin N. Hansen, AgroTech, Agro Food Park 15, DK-8200 Aarhus N. Phone: +45 8743 8429, E-mail: mnh@agrotech.dk.

External expert:
Arne Grønkjær Hansen, Danish Technological Institute, Kongsvang Allé 29, 8000 Århus C, Denmark. Phone: +45 7220 2142.
E-mail: arne-gronkjaer.hansen@teknologisk.dk.

2.6 Verification process

Verification and tests will be conducted in two separate steps, as required by the plans for the EU ETV programme. The steps in the verification are shown in Figure 2.

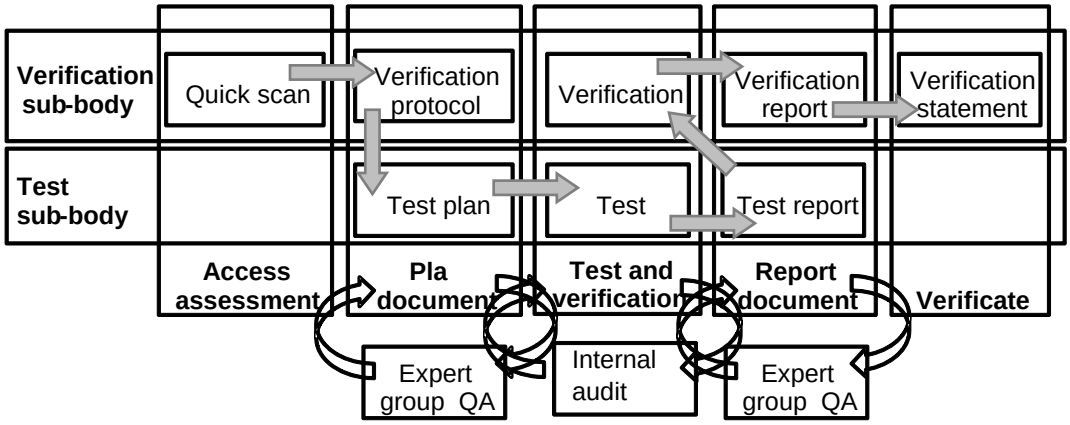

Figure 2. Verification steps.

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

This verification protocol, the test plan and the process document shall be seen as one consolidated verification description.

3 DESCRIPTION OF THE TECHNOLOGY

Since the 1990s there was increasing focus to reduce ammonia emission from live-stock housing systems and many different technologies were developed.

In housing systems with controlled ventilation systems one approach is to install air cleaners that remove part of the ammonia from the ventilation air and in some cases also odour and dust. However, in many Northern European countries and other parts of the world modern dairy production is taking place using cattle housing systems with natural ventilation. In such housing systems another approach than air cleaners is nec-essary. One way is to install technologies that add acid to the slurry to reduce pH.

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 equilib-rium is displaced to the left. By adding sulphuric acid to slurry pH is decreased and ammonia emission is reduced.

4 DESCRIPTION OF THE PRODUCT

The basic idea of the JH-Forsuring NH4+ is to add sulphuric acid to the slurry when it is still handled inside the livestock housing system. When acid is added pH is reduced and this leads to reduced ammonia emission.

The JH-acidification NH4 + can be adapted so it can be used for both cattle and pig slurry. In the present verification focus is put on the version of the acidification system that is adapted to a cattle housing system with a circular pit system.

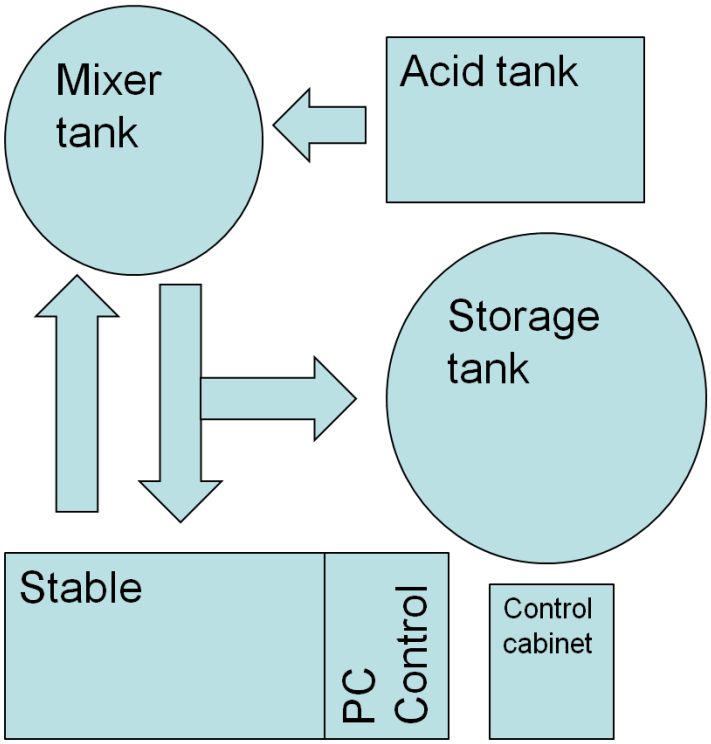

Figure 3. A diagram of the JH-acidification system for a cattle stable.

The slurry acidification system for cattle farms includes the following key elements:

- Acid tank, where the sulphuric acid (96 %) is stored until it is added to the manure.
- Mixing tank in which stirring, acid addition and pumping take place. The mixing tank is generally an existing tank.
- Newly produced manure is mixed with acidified manure and returned to the stable in the circular pit below the floor.
- Storage tank, where acidified manure is stored after the pumping process from the mixing tank.
- Control box and PC controller, which are used for configuration, data logging and alarms.

5 APPLICATION AND PERFORMANCE PARAMETERS

The intended application of the JH-Forsuring NH4+ system is defined in terms of the matrix, the target and the effect of the slurry acidification system.

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

A detailed description of the application can be seen in Appendix 3 – Application and performance parameter definitions.

5.1 Matrix

JH-Forsuring NH4+ is verified for acidification of fresh cattle slurry from housing systems with a circular pit system. Normally, the total solids content of cattle slurry is in the range of 7 – 11 %.

5.2 Targets

In the case of JH-Forsuring NH4+ the targets of the application are:

- Ammonia emission from the cattle housing system
- pH of cattle slurry in the pit system

5.3 Effects

In the case of JH-Forsuring NH4+ the effects are:

- Ammonia emission from the cattle housing system reduced by 40 % compared to the Danish normative emission factors
- pH of treated cattle slurry reduced compared to untreated cattle slurry.

5.4 Performance parameters for verification

The performance parameters provide the relevant information on the performance of the technology verified. In the case of the JH-Forsuring NH4+ the relevant performance parameter is:

- Ammonia emission from cattle housing system with a circular slurry pit system.

The claim put forward by the manufacturer is described in table 1.

Table 1. Performance claim by the technology supplier, Jørgen Hyldgård Staldservice.

Performance parameter	Claim
Reduction in ammonia emission from cattle housing systems with JH-Forsuring installed compared to the Danish normative emission factors.	Minimum 40%

In order to verify the performance claimed by the technology supplier a number of parameters have to be measured during the test. In table 2 the primary measurement parameter is presented and in table 3 the secondary parameters are presented. Secondary parameters include parameters that may influence the emission level of the primary environmental pollutants or which are relevant reference values. For each parameter analytical method, number of samples and sampling time are described.

Table 2. Primary measurement parameters.

Parameter	Analytical method	Number of samples	Sampling time
Ammonia	ISO 7150/2, NIOSH6015, VDI 2461/1 Innova 1412	6 measuring periods evenly distributed during the test over one year	Min 72 hours

Table 3. Secondary measurement parameters.

Parameter	Analytical method	Number of samples	Sampling time
CO_2	Photoacoustic multigas analyzer/Kitagawa Innova 1412	6	Minimum 72 hours for multigas analyzer.
H_2S	Jerome 631-X™	6	30 minutes
CH_4	Photoacoustic multigas analyzer, Innova 1412	6	Minimum 72 hours
N_2O	Photoacoustic multigas analyzer, Innova 1412	6	Minimum 72 hours
Ventilation rate	Tracer gas method with CO_2-balance	6	Minimum 72 hours
Temperature	VE10 - Temperature sensor	Continuous measurements in situ	
Relative humidity	VE14 universal input from VENG system combined with a humidity sensor.	Continuous measurements in situ	
pH in manure	Alpha pH 2000W pH meter	Continuous measurements in situ	
Manure parameters (M) • Amount [kg] [m³] • pH • DM [%] • Organic DM [%] • N [%] [g/kg] • TAN [%] [g/kg] • C:N • P, K • Additives/residues	Accredited laboratory, see chapter 4.2	6	
Wind • direction [°] • - speed [m/s]	VE14 universal input from Rotor weather station (Cup anemometer) Placed in kip	Continuous measurements in situ	

5.5 Additional parameters

Additional parameters are effects of the technology product that will be described but are considered secondary compared to the primary performance parameters.

5.5.1 Operational parameters

Operational parameters like noise, electrical and acid consumption are recorded during the test.

Table 4. Operational parameters.

Parameter	Analytical method	Number of samples	Sampling time
Noise	Brüel and Kjær modular precision sound analyzer type 2260. ISO 9001:2000	6	30 minutes
Electricity consumption	VE14 universal input from VENG system combined with a power meter	Continuous measurements in situ	
Acid consumption	VE14 universal input from VENG system combined with a power meter	Continuous measurements in situ	

5.5.2 Occupational health and safety

In general, technical installations in livestock housing - as all industrial machinery and equipment – must comply with the Machinery Directive (Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)). 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.

In detail the installations must satisfy the essential safety requirements contained in Annex I of the Directive, a correct conformity assessment must be carried out and a “Declaration of Conformity” must be given.

It is the responsibility of the manufacturer, importer or end supplier of the equipment to ensure that equipment supplied is in conformity with the Directive. In addition, Council Directive 89/655/EEC of 30 November 1989 concerns the minimum safety and health requirements for the use of work equipment by workers at work (amended 2007/30/EC) and places obligations on businesses and employers to take into account potential dangers to operators and other persons using or affected by machines and equipment.

In general terms, the directive requires that all equipment provided for use at work is: Suitable for the intended use; safe for use, maintained in a safe condition and, in certain circumstances, inspected to ensure this remains the case; used only by people who have received adequate information, instruction and training; and accompanied by suitable safety measures, e.g. protective devices, markings, warnings.

In addition, ISO 12100-2:2003 (Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles) defines technical principles to help designers in achieving safety in the design of machinery.

The safety instructions must be documented for example in a safety data sheet and must be observed carefully.

Before the beginning of any work, the technical installations must always be shut down. In addition, good ventilation and appropriate protective equipment, such as acid re-

sistant protective clothing, eye protection, etc. may be required. Moreover, one must make sure that protective installations, such as eye wash and shower units, are available and work properly.

5.5.3 User manual

The user manual for the JH-Forsuring NH4+ will be evaluated as part of the verification. For evaluation of the user manual the template in the AgroTech Test Centre Quality Manual can be used.

6 EXISTING DATA

6.1 Summary of existing data

There are some results from a few tests of slurry acidification technologies similar to the JH-Forsuring NH4+.

6.2 Quality of existing data

The data from the previous tests relate to other slurry acidification systems than the JH-Forsuring NH4+ or for other matrices. Thus, none of the previous tests are carried out for acidification of cattle slurry using JH-Forsuring NH4+. In addition, the previous tests are based on methods that vary from the DANETV verification protocol in a number of aspects.

6.3 Accepted existing data

No data from previous tests are included in this verification of the JH-Forsuring NH4+ slurry acidification system.

7 TEST PLAN REQUIREMENTS

Based on the application and performance parameter identification above the requirements for the test design were set. A detailed test plan shall be prepared separately based on the specification of the test requirements presented below. In general, the test plan shall be made so that it meets the requirements described in the VERA Test Protocol for Livestock Houlsing and Management Systems [9].

7.1 Test design

Case-control studies are not suitable for tests undertaken in naturally ventilated housing systems. Therefore ammonia emissions from the housing systems with JH-Forsuring installed shall be compared with normative ammonia emission factors. In the table below sampling strategy is described.

Table 5. Sampling strategy in cases where case-control within a farm is not possible.

Parameter	Requirement
Number of test farms	Minimum of four different farm locations.
Minimum size of test farm	The test farm shall be representative for farms in Northern Europe.
Measurement periods	At each test farm measurements shall be undertaken so that a yearly average of ammonia emission can be calculated.

7.1.1 Requirements for the test site

The test can be carried out at commercial cattle farms, which are representative form cattle farms in Northern Europe. The test shall be carried out under normal conditions that reflect how the JH-Forsuring NH4+ system will be used at cattle farm in full scale. The test sites proposed by the AgroTech test unit shall be approved by the verification responsible.

7.1.2 Sampling strategy

To calculate a yearly average for ammonia emission the test shall include minimum 6 measurement days randomly distributed in one year. In general, the test shall include approximately one measurement day each second month. Maximum one half of the measurement days shall be located during the first half of the growth circle.

7.2 Reference analysis

In general, all measurements and analytical methods must be documented satisfactory. To verify the performance with respect to ammonia a mass balance on nitrogen shall be made. The purpose is to compare the amount of nitrogen removed from the ventilated air with the amount of nitrogen measured in the slurry.

7.3 Data management

Data storage, transfer and control must be 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 will be subject to review by an internal and an external expert.

The quality assurance of the tests must include control of the test system and control of the data quality and integrity.

7.5 Test report

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

8 EVALUATION

8.1 Calculation of performance parameters

Both the relevant raw data and the processed data shall be included in the test report presented in relevant tables.

8.2 Evaluation of test data quality

The test system, data quality and integrity control will be evaluated against the requirements set in this protocol and the objectives set in the test plan.

The spread sheets used for the calculations will be subject to control on a sample basis (spot validation).

8.3 Compilation of additional parameters

8.3.1 Operational parameters

The operational parameters temperature, air humidity, electrical and acid consumption shall be recorded as part of the test.

8.3.2 User manual

For evaluation of the user manual the template in the AgroTech Test Centre Quality Manual can be used.

8.4 Occupational health and environment

Based on experiences during the test an evaluation of the JH-Forsuring NH4+ with respect to occupational health and safety can be included in the test report if it is judged relevant by the test organisation.

9 VERIFICATION SCHEDULE

The verification is planned for 2011-2012. The overall schedule is presented in table 6 below.

Table 6. Schedule for verification of JH-Forsuring NH4+.

Task	Timing
Quick scan and contract negotiation	January – February 2011
Verification protocol and test plan	February - March 2011
Test and analyses	March 2011 – February 2012
Test reporting	March – April 2012
Verification report	May – June 2012
Report document review	June - July 2012
Verification statement	August 2012

10 QUALITY ASSURANCE

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

Table7. Quality assurance plan for the verification of JH-Forsuring NH4+

Task	Internal experts	External expert
Plan document including verification protocol and test plan	Thorkild Q. Frandsen Martin N. Hansen, AgroTech	Arne Grønkjær Hansen, Danish Technological Institute
Report document including test report and verification reports	Thorkild Q. Frandsen Martin N. Hansen, AgroTech	Arne Grønkjær Hansen, Danish Technological Institute

Internal review of verification protocol, verification report, test plan and test report is done by Thorkild Q Frandsen and Martin N. Hansen. No test system audit is planned for this verification task. External review is done by the external reviewer assigned for this verification task, Arne Grønkjær Hansen, Danish Technological Institute (DTI).

Reviews can be done using the DANETV review report template.

A P P E N D I X 1

Terms and definitions used in the verification protocol

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 center 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

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[9] VERA Secretariat, 2009: Test Protocol for Livestock Housing and Management Systems. Version 1. 2009-12-09. VERA Secretariat, Charlottenlund, Denmark. 42 pp.

[10] Miljøstyrelsen (2011): Bekendtgørelse om ændring af bekendtgørelse om tilladelse og godkendelse m.v. af husdyrbrug. BEK nr 291 af 06/04/2011. (In Danish).

A P P E N D I X 3

Application and performance parameter definitions

This appendix defines the application and the relevant performance parameters as input for the verification and test of JH-Forsuring NH4+ following the DANETV method.

1. Applications

The intended application of the JH-Forsuring NH4+ system is defined in terms of the matrix, the target and the effect of the slurry acidification system.

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

1.1 Matrix

The matrix is the type of material that the product is intended for. JH-Forsuring NH4+ is verified for acidification of fresh cattle slurry from housing systems with a circular pit system. Normally, the total solids content of cattle slurry is in the range of 7 – 11 %.

1.2 Targets

In the case of JH-Forsuring NH4+ the targets of the application are:

- Ammonia emission from the cattle housing system
- pH of cattle slurry in the pit system

1.3 Effects

The effects describe how the targets are affected by the technology product.

In the case of JH-Forsuring NH4+ the effects are:

- Ammonia emission from the cattle housing system reduced by 40 % compared to the Danish normative emission factors
- pH of treated cattle slurry reduced compared to untreated cattle slurry.

1.4 Exclusions

JH-Forsuring can be used for acidification of other slurry types like sow slurry and slurry from fattening pigs. However, these matrices differ from cattle slurry in a number of aspects.

Consequently, the results of this verification of JH-Forsuring for acidification of cattle slurry are not necessarily valid for JH-Forsuring used for acidification of slurry from sows and fattening pigs. Additional tests are necessary to verify the performance of JH-Forsuring used for acidification of such matrices.

2. General performance requirements

According to the Danish regulation of livestock production units [10] there is a main rule for ammonia reduction: For new housing systems a 30 % reduction in ammonia emission compared to a reference housing system is a prerequisite in order to achieve environmental permission.

3. State of the art performance

Other technologies can be used to reduce ammonia emission from cattle housing systems. The Danish Environmental Protection Agency has published a list of environmental technologies for reduction of negative impacts of livestock production. For each technology the environmental performance is described.

When it comes to reduction of ammonia emission from naturally ventilated cattle housing systems the following technologies are mentioned on the technology list:

- Infarm acidification system: 50 % reduction of ammonia emission
- Manure scraper systems: Up to 25 % reduction of ammonia emission

4. Performance parameter definitions

The performance parameters are defined in section 5.4 above.