Jørgen Hyldgård Staldservice A/S

JH-FORSURING NH4+

Test report

Version 1-5

Document information

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1 TABLE OF CONTENTS

2 INTRODUCTION

This test report describes the results from test under the test plan developed for verification of an acidification system following the AgroTech DANETV Test Centre Quality Manual.

2.1 Verification protocol reference

The test plan was prepared to meet the requirements defined in the DANETV verification protocol for JH-FORSURING NH4+ and the VERA verification protocol for Livestock Housing and Management Systems (VERA, 2011).

2.2 Name and contact of vendor

The JH-FORSURING NH4+ is developed and produced by Jørgen Hyldgaard Staldservice A/S, Nørgårdsvej 18, 7500 Holstebro. Contact person of Jørgen Hyldgaard Staldservice is Ken Hyldgaard. 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/test responsible

DANETV verification Centre AgroTech, Agro Food Park 15, 8200 Aarhus N, Denmark.

Test responsible: Mathias Andersen, Agro Food Park 15, 8200 Aarhus N, Denmark,
E-mail: mxa@agrotech.dk, Phone: +45 8743 8470.

Test staff: Linda Veggebro, AgroTech, Agro Food Park 15, 8200 Aarhus N, Denmark.
E-mail: liv@agrotech.dk. Phone: +45 3092 1795.

2.4 Technical experts

The technical experts assigned to this test and responsible for review of test plan and test report includes:

Internal expert:
Thorkild Qvist Frandsen, AgroTech, Udkærsvej 15, DK-8200 Århus N. Phone: +45 8743 8468 E-mail: tqf@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.

3 TEST DESIGN

3.1 Test site

The JH-FORSURING NH4+ is tested in full-scale on 4 commercial dairy farms during a 12 months period each covering both summer and winter temperatures.

3.2 Test site

3.2.1 Characterization of the test site

Four commercial dairy farms are used as four different the test sites. The capacity of the housing systems is between 150 – 550 cows. Three of the test sites have Holstein-Friesian cattle and one has a mixture have approximately 20 % Holstein-Friesian cattle and 80 % Jersey cattle.

The flooring systems of all the dairy farms are slatted floor. The manure from the cattle is collected in a circular pit under the slats. The floor is either scraped with a line scraper or by cleaning robots.

The ventilation system is natural ventilation with regulated curtains or lamella openings in the sides. The number of cattle heads indicated in table 1-4 is the present number before test start.

The bedding material is either straw or sawdust. The cows are all fed with a mix of corn silage and grass silage balanced with soybean meal and wheat.

Tables 1 to 4 give an overview of key characteristics of the dairy farms used for the test.

Table 1. Key characteristics of the dairy farm no. 1 used for test.

Parameter	Test site characteristics
Farm owner	Milthers Lodahl
Address	Herningvej 66, Trandum 7800 Skive
Contact Info	Phone: 9754 4152 mob.: 2013 41 52
CHR no.	66571
Grazing cows in summer	No.
Animal places	236
Number of cows	140
Weight range (kg)	600-650
Milk production l/year/cow	10.500
Bedding material	Straw pellets (Easy Strø)
Space provided per animal	1,25 m wide 2,8 m long
Number of Heifers	60
Number of cows in dry period	15
Number of calves	0
Floor design	Slats
Manure removal system	Circular recirculation manure pit
Scraper systems on top of slats	Robot Scraper
Cooling of slurry	No.
Feed composition	45% corn silage 45% grass silage, soybean meal, wheat
Feed analysis	3 x per year
Ventilation	Natural ventilation with automatically regulated curtains

Table 2. Key characteristics of the dairy farm no. 2 used for test.

Parameter	**Test site characteristics**
Farm owner	Søren Hansen
Address	Sevelvej 85 7830 Vinderup
Contact Info	mob.: 4057 6877
CHR no.	57194
Grazing cows in summer	No.
Animal places	190 (180)
Number of cows	190
Weight range (kg)	600-650
Milk production l/year/cow (km)	10.300
Bedding material	Sawdust
Space provided per animal	1,25 m wide 2,8 m long
Number of Heifers	0
Number of cows in dry period	0
Number of calves	0
Floor design	Slats
Manure removal system	Circular recirculation manure pit
Scraper systems on top of slats	Line scraper
Cooling of slurry	No.
Feed composition	2/3 corn silage 1/3 grass silage, wheat, soy-bean meal
Feed analysis	Once per month
Ventilation	Natural ventilation with lamella openings in both sides, not adjustable. Can be supple-mented with opening of windows

Table 3. Key characteristics of the dairy farm no. 3 used for test.

Parameter	Test site characteristics
Farm owner	Jens Erik Damtoft
Address	Struervej nr. 1 7830 Vinderup
Contact Info	mob.: 6175 2767
CHR no.	57133
Grazing cows in summer	No.
Animal places	375
Number of cows	210
weight range (kg)	600-650
Milk production l/year/cow	10.700
Bedding material	Sawdust
Space provided per animal	1,25 m wide 2,8 m long
Number of Heifers	180
Number of cows in dry period	18
Number of calves	0
Floor design	Slats
Manure removal system	Circular recirculation manure pit
Scraper systems on top of slats	line scraper
Cooling of slurry	No.
Feed composition	2/3 corn silage 1/3 grass silage
Feeding analysis	Once per month
Ventilation	Natural ventilation with manually regulated curtains

Table 4. Key characteristics of the dairy farm no. 4 used for test.

Parameter	Test site characteristics
Farm owner	Knud Erling Birch
Address	Ejsingholmvej 35 7830 Vinderup
Contact Info	Phone: 9744 6395 mob.: 2091 6395
CHR no.	54645
Grazing cows in summer	No.
Animal places	520
Number of cows	520
weight range (kg)	450-600
Milk production	8.270
Bedding material	Sawdust
Space provided per animal	1,25 m wide 2,8 m long
Number of Heifers	0
Number of cows in dry period	0
Number of calves	0
Floor design	Slats
Manure removal system	Circular recirculation manure pit
Scraper systems on top of slats	Line scraper
Cooling of slurry	No.
Feed composition	½ corn silage ½ grass silage, soybean meal, wheat
Feeding analysis	Once per month
Ventilation	Natural ventilation with automatically regulated curtains

Figure 1 - 4 provides an overview of the construction of the 4 different dairy farms used for the test.

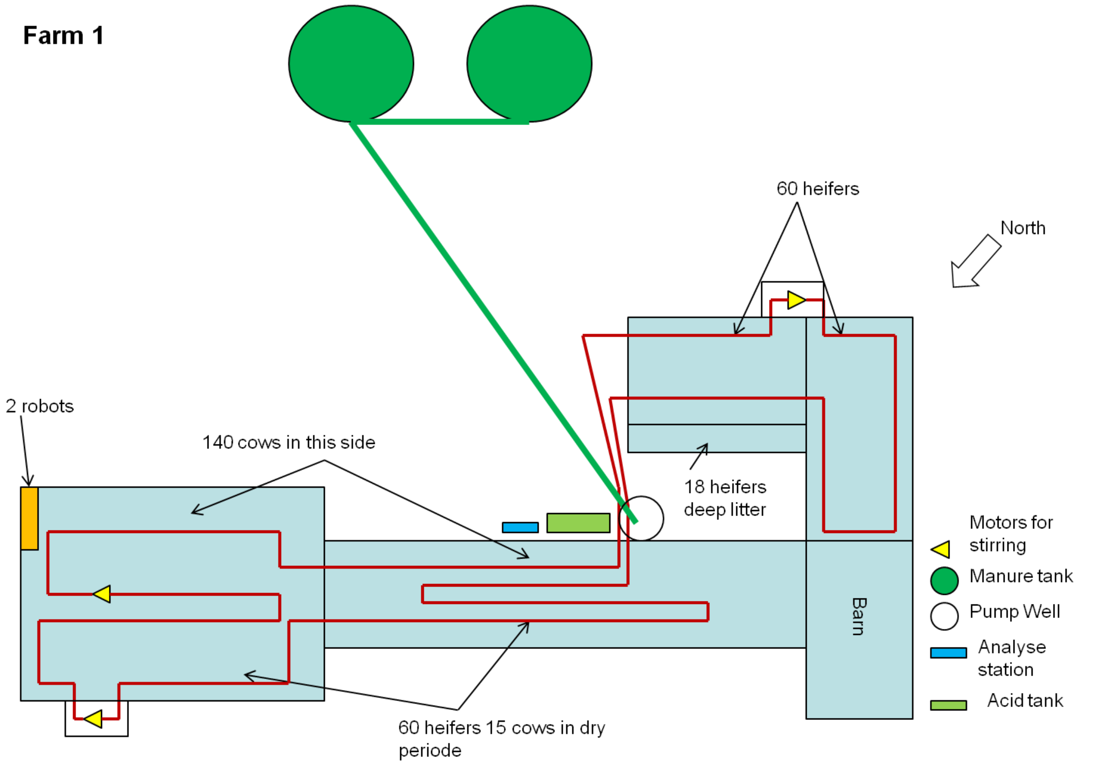

Figure 1 shows a diagram of the building design at farm 1

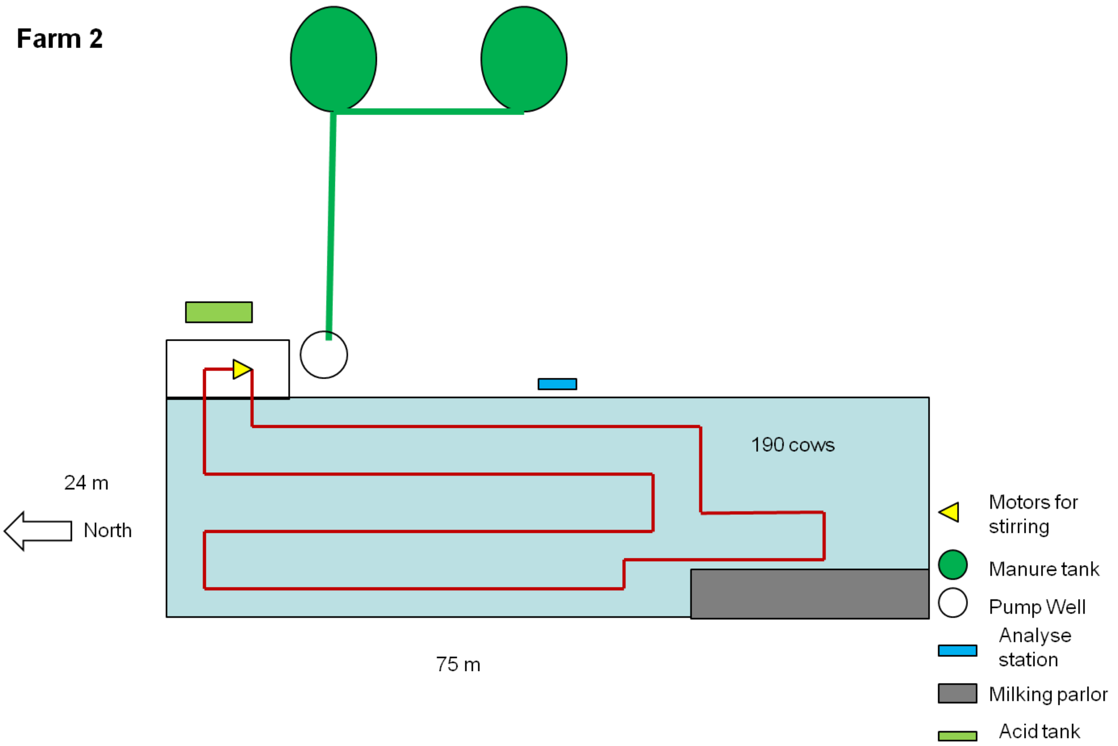

Figure 2 shows a diagram of the building design at farm 2

Farm 3

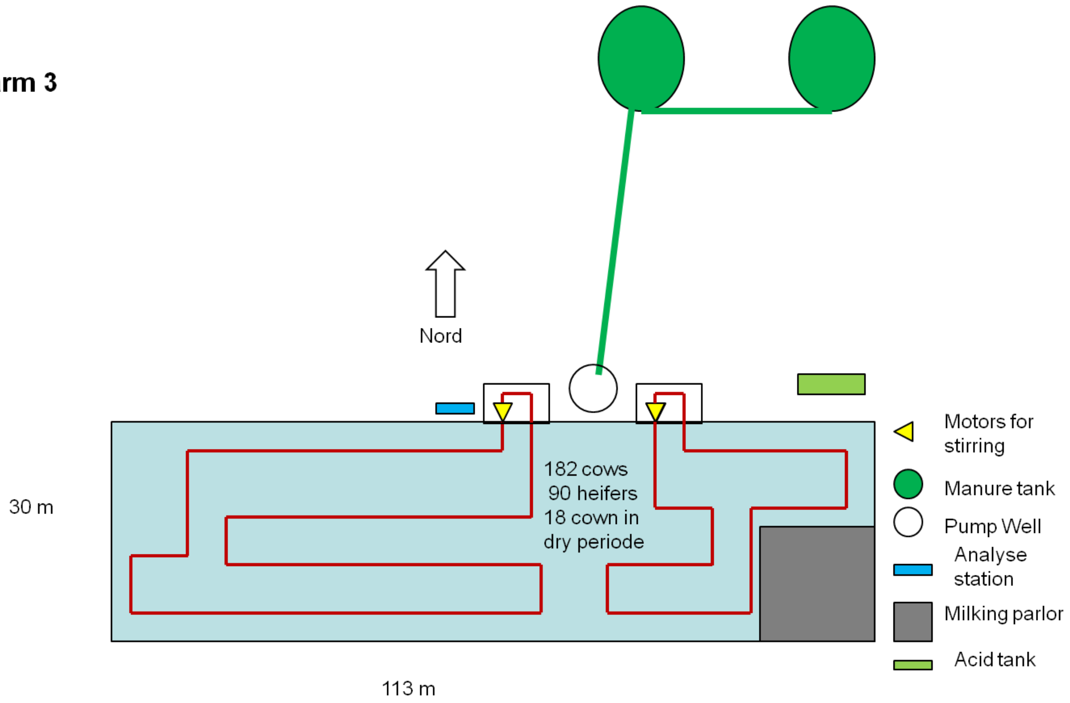

Figure 3 shows a diagram of the building design at farm 3

Farm 4

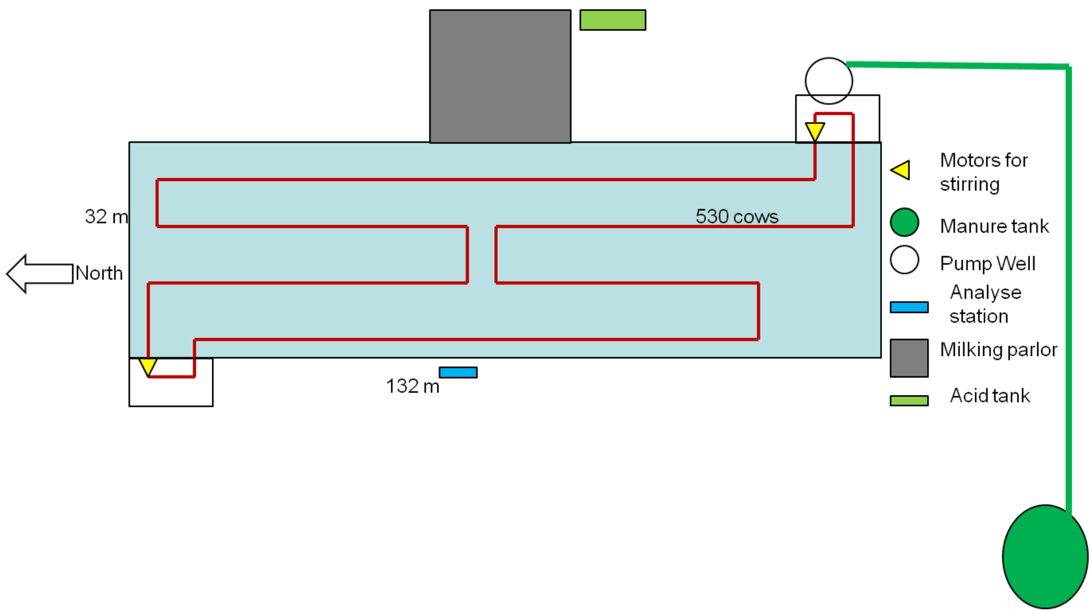

Figure 4 shows a diagram of the building design at farm 4

3.2.2 Addresses

The test has taken place at the following farms:

Farm no. 1
Milther Lodahl
Herningvej 66, Trandum
7800 Skive

Farm no. 2
Søren Hansen
Sevelvej 85
7830 Vinderup

Farm no. 3
Jens Erik Damtoft
Struervej nr. 1
7830 Vinderup

Farm no. 4
Knud Birch
Ejsingholmvej 35
7830 Vinderup

3.2.3 *Descriptions*

Functional description of JH-acidification
Jørgen Hyldgaard, Housing Service A/S, has developed a new technique called JH-acidification NH4 +, which is an acidification system for both cattle and pig manure. The current acidification system has been developed for dairy production with a circular pit system.

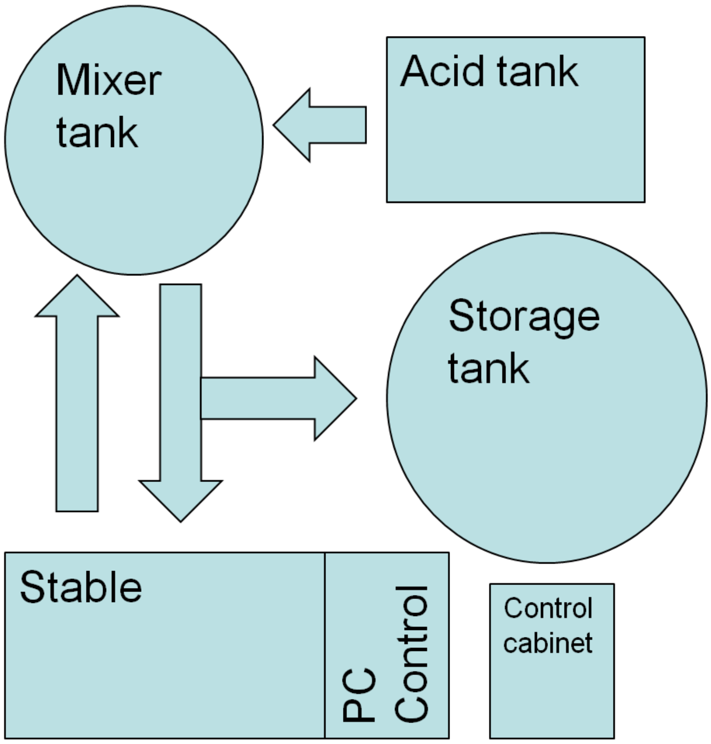

Figure 5. A diagram of the JH-acidification system for a cattle stable, (Andersen, 2010).

The manure 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.

The acidification system works as follows:

At the present time every day of the year acidification takes place in the following chronological order:

1. The two pH electrodes which are placed in the mixer tank are flushed with water.

2. Stirring of the manure in the mixing tank begins and manure from the mixing tank is pumped into the circular pit in the stable.

3. After 10-20 minutes of stirring, sulphuric acid (96 %) is added from the acid tank to the manure in the mixing tank. A metering pump is used for this purpose.

4. The stirring stops after 30-60 minutes. At this time the pH value has reached its set point at pH 5.5.

5. After 10 minutes break the pH is measured in the mixing tank.

Dependent on the time when the daily acidification is set to run, manure is pumped into the storage tank. The manure is pumped to the storage tank until a preset minimum level in the mixing tank is reached.

All processes such as stirring, pumping, addition of sulfuric acid and pumping to the storage tank are controlled automatically. The control cabinet manages the acidification. Logging of all measured pH values are uploaded to a web server, which can be accessed from everywhere. This gives an opportunity to continuously monitor and verify that the installation works properly (Andersen, 2010).

The acid used for acidification of the manure is a 96 % sulfuric acid technical grade, see appendix 5, Data sheet for sulphuric acid.

3.3 Tests

3.3.1 Test methods

The overall principle for testing the performance of the JH-FORSURING NH4+ is to measure the emission of ammonia from dairy farms with the acidification technology installed and compare it to normative emission factors for similar housing systems. As we are dealing with naturally ventilated dairy farms with different building design and capacity case-control studies are not be suitable. In this case we have monitor 4 different test farms equipped with the acidification system. The required test period is one year and the emission factors are calculated accordingly.

For reference and comparison the Danish norm emission factors will be used for the respective housing systems.

Emission measurements require the measurement of ventilation rates. In naturally ventilated building, ventilation rates cannot be measured by fans and have to be estimated by other methods like the tracer gas methods.

The tracer gas used in this test is CO_2 produced from the animals following the CO_2 balanced method. The production of CO_2 can be estimated from the size of the animals and the milk production. The tracer gas method assumes even distribution of gases and that the dilution rate of CO_2 is equal to the one from NH_3 (S. Pedersen & K. Sällvik, 2002).

The effect is measured over the basis of 12 months covering measurements during summer period and measurements during winter period equal divided throughout the year. The technology is tested at 4 different dairy farms. The primary performance parameter is ammonia.

In addition to the primary performance parameters a number of operational parameters are measured throughout the test periods. A list of the operational parameters is found in section 4.2.

3.3.2 Test staff

The test staffs involved in the test of JH-FORSURING NH4+ are:

Mathias Andersen, AgroTech, Agro Food Park 15, Skejby, 8200 Århus N.Phone: +45 3092 1786. E-mail: mxa@agrotech.dk

Søren Gustav Rasmussen, AgroTech, Agro Food Park 15, Skejby, 8200 Århus N. Phone: +45 2172 7942. E-mail: sgr@agrotech.dk

Linda Veggebro, AgroTech, Agro Food Park15, Skejby, 8200 Århus N.
Phone: +45 3092 1795. E-mail: liv@agrotech.dk

3.3.3 Test schedule

The preliminary test schedule and the timetable for measuring dates are presented in table 5 and 6. The final test schedule and timetable for measuring dates are presented in the amendment and deviation report, appendix 7.

Table 5. Preliminary test schedule.

Task/md-year	mar-11	apr-11	may-11	jun-11	jul-11	aug-11	sep-11	okt-11	nov-11	dec-11	jan-12	feb-12	mar-12	apr-12
Test plan	x													
Installation and pre-testing	x													
Start test periode (7.marts.2011)	x													
Sampling periode		x		x		x		x		x		x		
End of test period (20.feb.2012)												x		
Test report draft							x							
Test report quality assurance													x	
Test report final version														x

Table 6. Preliminary timetable for measuring dates:

	Farm 1	Farm 2	Farm 3	Farm 4
Period 1_April				
Start measurement	04 April 2011	07 April 2011	11 April 2011	14 April 2011
Stop measurement	07 April 2011	11 April 2011	14 April 2011	18 April 2011
Period 2_June				
Start measurement	06 June 2011	09 June 2011	14 June 2011	17 June 2011
Stop measurement	09 June 2011	14 June 2011	17 June 2011	21 June 2011
Period 3_August				
Start measurement	08 August 2011	11 August 2011	15 August 2011	18 August 2011
Stop measurement	11 August 2011	15 August 2011	18 August 2011	22 August 2011
Period 4_October				
Start measurement	03 October 2011	06 October 2011	13 October 2011	17 October 2011
Stop measurement	06 October 2011	10 October 2011	17 October 2011	20 October 2011
Period 5_December				
Start measurement	05 December 2011	08 December 2011	12 December 2011	15 December 2011
Stop measurement	08 December 2011	12 December 2011	15 December 2011	19 December 2011
Period 6_February				
Start measurement	06 February 2012	09 February 2012	13 February 2012	16 February 2012
Stop measurement	09 February 2012	13 February 2012	16 February 2012	20 February 2012

3.3.4 Test equipment
Equipment used for the test is described in section 4.2. Analytical methods are described in section 4.2.

3.3.5 Type and number of samples
The sample types and the number of samples to be taken are described in section 4.2.

3.3.6 Operation conditions
Operational parameters like temperature, air humidity, electrical and acid consumption are recorded during the test. A description of the measurement of operational parameters can be found in section 4.3.

3.3.7 Operation measurements
The measurement of operational parameters is described in section 4.3.

3.3.8 Product maintenance
Maintenance of the JH-FORSURING NH4+ during the test period is the responsibility of the farm owner. If the farm owner identifies a problem with the JH-FORSURING NH4+ that the farmer cannot solve by himself he shall contact Jørgen Hyldgård Stald-

service A/S and also inform AgroTech´s test staff. As the company marketing the JH-FORSURING NH4+ in Denmark Jørgen Hyldgård Staldservice A/S has the responsibility of repairing the JH-FORSURING NH4+ in case of break down during the test, after they have been informed by the farmer.

Irregularities and break downs during the test period are recorded by AgroTech's test staff.

See user manual, Appendix 8.

3.3.9 Health, safety and wastes

Laboratory work during the test will be done according to the Danish rules for safe occupational health and the European regulations regarding work with chemicals. Field work will be done according to Danish rules for safe field work.

Chemicals used for the test are discarded according to Danish regulations for chemical waste by collection and destruction.

It is judged by the AgroTech test staff that the use of the JH-FORSURING NH4+ does not imply any special health, safety or waste issues when user manual is followed and technical grade sulphuric acid is used, see Appendix 5 and 8.

4 REFERENCE ANALYSIS

Slurry samples from the dairy farms where JH-FORSURING NH4+ is installed is analysed by Eurofins Danmark. Address: Smedeskovvej 38, DK-8464 Galten, Denmark. Phone: +45 7022 4266. E-mail: info@eurofins.dk.

Reference samples are analysed Analytech Miljølaboratorium A/S, Bøgildsmindevej 21, 9400 Nørresundby. From every 6 manure samples 1 is controlled by the reference laboratory.
See appendix 3.

4.1 Analytical parameters

The primary analytical parameters are presented in table 6. The operational parameters (conditional measurement parameters) are presented in table 7.

4.2 Analytical methods

In table 6 the analytical methods of the primary parameter are presented. In table 7 the analytical methods of the operational parameters are presented.
Table 6 shows the primary measurement methods consisting of the primary environmental pollutant emitted from the livestock housing unit which is the primary target of the environmental technologies for the dairy farms. As seen in Table 6 the primary measurement parameter is ammonia. This technology is not expected to have an overall negative effect on odour nor dust. It has been found that acidification of pig slurry does not contribute to an elevated odour emission (Pedersen, 2004), (Pedersen &

Albrechtsen, 2012). Moreover it has been shown that the microbial turnover of organic material in sulphuric acid-treated pig slurry (pH 5.5) is reduced by more than 96% in terms of oxygen consumption, methane production and sulphate reduction compared to untreated pig slurry, (Ottosen et al., 2009). This will theoretically reduce the emissions of VFA's. However acidification may contribute to release of hydrogen sulphide from the slurry, which is why this parameter will be measured. H_2S could be indicator for high odour, and is often correlated. Parameters for odour and dust are set to zero by default and will not be measured in this test.

Table 7 shows the operational parameters, which include parameters that may influence the emission level of the primary environmental pollutant or which are relevant reference values. In addition the table includes other secondary environmental pollutants.

All analytic parameters listed in those 2 tables are measured for each of the 4 different dairy farms.

Table 7. Primary analytical parameters and corresponding analytical methods.

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 8. Operational and secondary parameters and corresponding analytical methods.

Parameter	Analytical method	Number of samples	Sampling time
CO_2	Photoacoustic multigas analyzer, 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	
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	
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, appendix 3	6	
Wind • direction [°] • - speed [m/s]	VE14 universal input from Rotor weather station (Cup anemometer) Placed in kip	Continuous measurements in situ	

Ammonia analysis

The ammonia concentration is measured with INNOVA 1412, photoacoustic gas detector. This method is used when more frequent continuous measurements, i.e., on a 1 to 5 min sampling basis, are required for the sample air.

In the photoacoustic gas analyzer the exhaust air is continuously sampled at a known flow rate and the concentration of NH_3 in the sample air is determined with the photoacoustic gas analyzer. The NH_3 measurements are corrected for temperature and interference with H_2O and CO_2 , (LumaSense Technologies, 2011).

Detection limit and uncertainty

The accuracies of the two techniques described above, as expressed by the standard error under repeatability conditions, show levels that are within the 1% to 3% range, (Mosquera et al., 2011).

Detection limit: 0.1 ppm for ammonia, (LumaSense Technologies, 2012).
One key issue is to estimate the ventilation rate and then to quantify the gaseous emissions. The quantification of ammonia emission from livestock houses with natural ventilation systems is a big challenge and it is associated with some uncertainties. The main issue is to measure the ventilation rate. In this test, CO_2 balance is used to calculate the ventilation rate, which is the most commonly used method for continuous measurements in naturally ventilated livestock buildings (S. Pedersen & K. Sällvik, 2002). The CO_2-balance has several error sources such as the calculation of metabolic energy, the CO_2 produced per energy unit, the amount of CO_2 produced by manure, and the location of the CO_2 sampling points, (Samer et al., 2011).

Ventilation rate

Ventilation rates are required to estimate the amount of gases emitted from dairy buildings. The rate of production (*P* in m^3h^{-1}) of a specific gas in a dairy building is estimated as:

$$P = q_V\,(C_g - C_{out}) = q_V\,\Delta C$$

where q_V (m^3h^{-1}) is the ventilation rate, and C_g (m^3/m^3) and C_{out} (m^3/m^3) are the concentrations of the gas inside and outside the dairy structure respectively. P is calculated from a bow formula under the assumption: 1 HPU = 1000 W = 0.185m^3 CO_2 h^{-1} , (S. Pedersen & K. Sällvik, 2002). 1 HPU is approximately equal to 1.3 full-grown Danish cows.

Heifers

$$\Phi_{tot} = 7.64\,m^{0.69} + Y_2\left[\frac{23}{M} - 1\right]\left[\frac{57.27 + 0.302\,m}{1 - 0.171\,Y_2}\right] + 1.6 \times 10^{-5}\,p^3\text{, W}$$

Y_2 = daily gain, 0.6 kg/day.

Cows

$$\Phi_{tot} = 5.6\,m^{0.75} + 22Y_1 + 1.6 \times 10^{-5}p^3\text{, W}$$

Y_1 = milk production, kg/day

P = Days of pregnancy.

Days of pregnancy can be neglected. Heifers are arranging 580 W and calves 120 W. A calve is defined as 0-6 month old.

For the above mentioned gas production rate to be valid, the air in the dairy building must be ideally mixed i.e. C_g should be constant all over the building and must not change with time. This is often not the case in real situations. Therefore it is necessary to sample at different locations to get a representative sample of the gas concentration in a dairy buildings.

Sample location for air

Below is a diagram of the sampling procedure. Sampling tubes are installed longitudinal in 3 parallel lines through the stable. Each line has several inlets. All the sample tubes are connected to the photoacoustic gas analyzer in the mobile analyse station. If ΔC is higher than 109 ppm the sample is chosen to represent the inside concentration. The line that is fares away from the luv side will normally always be chosen, because the sample inlet on this line has the highest concentration.

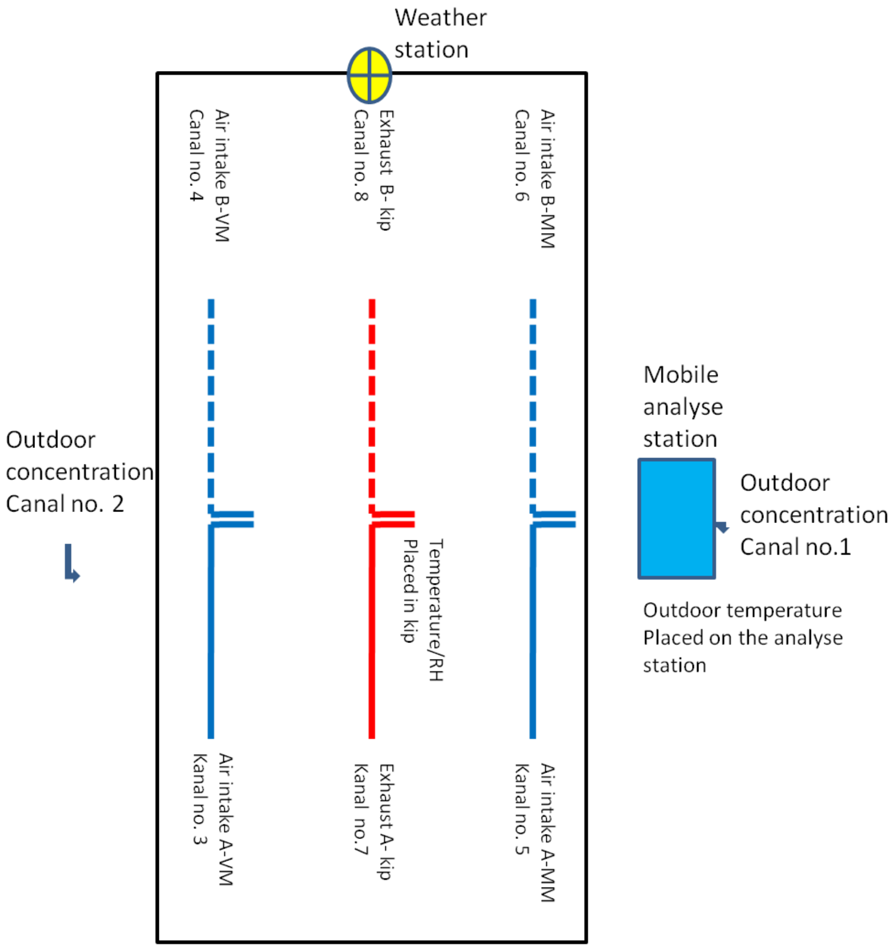

Figure 6 shows a diagram over a dairy building seen from the top and the position of the sampling tubes

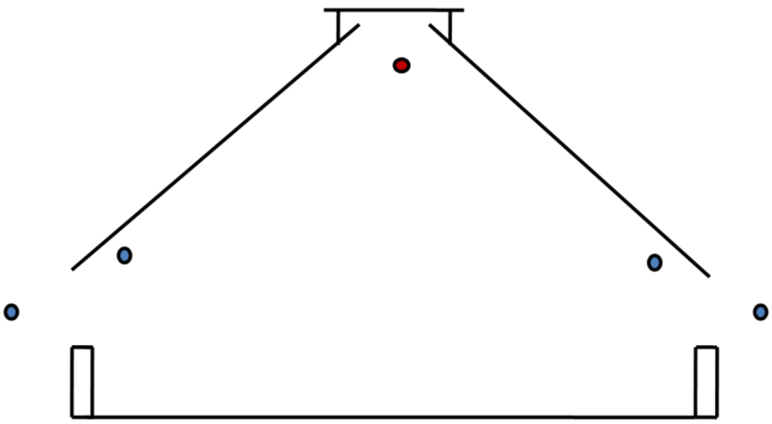

Figure 7 shows a cross section of the stable and the position of the lines of sampling tubes.

For further information about the emission measurements see (Malene Juul Rasmussen, 2011).

Sample location for slurry

Slurry samples can be obtained from the mixing tank near the acidification system. Sampling is preferably done shortly after mixing. A ten-litre bucket is used to obtain a representative sample. The manure is then homogenized and poured into 2 one-litre bottles, see Figure 5.

4.3 Analytical performance requirements

In table 9 the limits of detection and in some cases the uncertainty of the analytical methods are presented.

Table 9. Limits of detection for the analytical methods used.

Parameter	Analytical method	Limit of detection	Uncertainty
Ammonia	ISO 7150/2	0,1 ppm	---
CO_2	Photoacoustic multigas analyzer	1,5 ppm	---
H_2S	Jerome 631-X™	0,003 ppm	5 % RSD
CH_4	Photoacoustic multigas analyzer	0,4 ppm	---
N_2O	Photoacoustic multigas analyzer	0,03 ppm	---
Ventilation rate	CO2-balance	---	2-50 %, (Ngwabie, 2011)
Temperature	VE10 - Temperature sensor	0,05 °C	0,2 °C
Relative humidity	VE14 universal input from VENG system combined with a humidity sensor.	---	---
Noise	Brüel and Kjær modular precision sound analyzer type 2260. ISO 9001:2000	(Arbejdstilsynet, 2010)	---
Electricity consumption	VE14 universal input from VENG system combined with a power meter	---	---
Acid consumption	flow meter	---	---
pH in manure	Alpha pH 2000W pH meter	---	---

Note: RSD: Relative standard deviation.

4.4 Preservation and storage of samples

Slurry samples
Slurry samples can be obtained from the mixing tank near the acidification system (see figure 5). Sampling is preferably done shortly after mixing. A 10 litre bucket is used to obtain a representative sample. The manure is then homogenized and poured into 2 one litre bottles.

The samples are stored and frozen until they are sent to analysis at the the laboratory. The samples are frozen down as soon as possible after sampling.

5 DATA MANAGEMENT

Data management including filing and archiving procedures are described in the Agro-Tech Test Centre Quality Manual.

5.1 Data storage, transfer and control

Some data are collected and written down at the test site. Appendix 6 includes data recording sheets to be used for registration of data at the test site.

Some data are collected by electronic means at the test site and send via internet to a PC in the AgroTech main office.

Results from external laboratories are sent electronically by email or in paper version by current mail.

Table 10. Data compilation and storage summary.

Data type	Data media	Data recorder	Data record timing	Data storage
Test plan and test report	Protected pdf-files.	Test responsible	When approved	Files and archives at AgroTech
Data manually recorded at test site	Data recording forms	Test staff at test site	During collection	Files and archives at AgroTech
Calculations	Excel files	Test responsible, AgroTech	During calculation	Files and archives at AgroTech
Analytical reports	Paper / pdf-files	Test responsible, AgroTech	When received	Files and archives at AgroTech

6 QUALITY ASSURANCE

The test will be follow the AgroTech Test Centre Quality Manual, which is ISO 9001 certified.

6.1 Test plan review

The test plan has been subject to internal review by the verification responsible from AgroTech Test Centre.

The technical expert assigned to this verification task has done external review of the test plan.

6.2 Performance control – reference analysis

To verify the performance with respect to ammonia a mass balance on nitrogen is made. The purpose is to compare the amount of nitrogen removed from the air with the amount of nitrogen lost from the slurry.

6.3 Test system control

The stability of the test equipment will be controlled continuously by supervision and recording of data. Procedures for ensuring that test facilities and equipment are calibrated and fit for the purposes are described in the Quality Manual for the Laboratories of AgroTech. These procedures are subject to internal audits from the AgroTech Management.

6.4 Data integrity check procedures

All transfers of data from printed media to digital form and between digital media are checked by spot check undertaken by test responsible. If errors are found in a spot check, all data transfers from the specific data collection are checked.

6.5 Test system audits

Internal audits from AgroTech will be done following the procedure described in the AgroTech Test Centre Quality Manual.

6.6 Test report review

The test report has been subject to internal review by the verification responsible from AgroTech Test Centre.

External review of the test report has been done by the technical expert assigned to this verification task as part of the review of the verification report. The verification report includes the full test report as an appendix.

7 TEST REPORT

The test report follows the template of the AgroTech Test Centre Quality Manual and will be included as an appendix in the verification report.

7.1 Test site report

No specific test site report will be made unless it is judged necessary to make this report later. At the test site data are collected and registered on data reporting forms. Templates for data reporting forms are included in this test plan in Appendix 6.

7.2 Test data report

No specific test data report will be made unless it is judged necessary to make this report later. All data recorded during the test including results from external analytical laboratories will be gathered and archived according to the AgroTech Test Centre Quality Manual.

7.3 Amendment report

In the test report there is a section on amendments to and deviations from the test plan. This section will compile all changes of the test plan occurring before testing with justification of deviations and evaluation of any consequences for the test data quality.

7.4 Deviations report

In the test report there is a section on amendments to and deviations from the test plan. This section will compile all changes of the test plan occurring during testing with justification of deviations and evaluation of any consequences for the test data quality.

8 TEST RESULTS

8.1 Test performance summary

The data recorded during the test have been subject to the following statistical modelling.

The measured emissions are tested with Shapiro-Wilk normality to ensure that the data are Gaussian distributed. There is performed standard model control of the assumption, that the data are Gaussian distributed.

All estimates and tests are made with raw data without transformation.

For the measured ammonia emission, standard confidence intervals are calculated. 5% 95% confidence interval is chosen and reflects a significance level of 0.05, and the confidence interval contains the parameter values that, when tested, should not be rejected with the same sample.

For the reduction the hypothesis of zero reduction is tested by the Student's T-test, and the resulting confidence interval for the sample mean is used.

8.2 Test measurement summary

Table 11. Results of ammonia reduction between the 4 farms during one year including mean standard variation, T-test and probability. The reduction is calculated as the reduction from treated stables to normative values, relative to the normative value.

Reduction	Reduction, % Emission, HPU	Reduction, % Emission, animal	Reduction, % Emission, LU	mean temp. ºC
Stald 1 *Milther Lodahl*	16.70	16.63	16.77	12.7
Stald 2 *Søren Hansen*	23.66	23.66	23.66	11.3
Stald 3 *Jens Erik Damtoft*	6.93	7.07	7.03	11.9
Stald 4 *Knud Birch (jersy)*	21.11	21.29	21.29	11.4
Mean year *17/3/11 – 3/4/12*	17.10	17.16	17.19	11.8
Std. Variation	7.36	7.34	7.35	0.6
t	4.36	4.37	4.37	36.97
Pr(>|t|)	0.02231*	0.02219*	0.02217*	4.352e-05***

Reduction: NH_3 reduction across farms and in the measured period was significant in the available data. This applies to all three emission measurement parameters: emission, HPU (g NH_3/HPU/t) emissions, animal (kg NH_3/year/animal) and emission, LU (Kg NH_3/year/LU), see Table 11. Example: The estimated reduction measured as emissions, HPU (g NH_3/HPU/t) was 17.10 % (p = 0.022*).

Farm effect: Farm effect was not significant according to the data (p> 0.05, see Table 11).

Effect of temperature: The temperature changed systematic and independent of farm over the measured period of the available data using the following formula: Temperature in °C = -13.5 °C -14.9 * period^2 + 14.0 * Periode^3 (R^2 = 0.91). Temperature could in the available data explain a significant portion of the variation in all three emission measurement parameters: emission, HPU (g NH_3/HPU/t) emissions, animal (kg NH_3/year/animal) and emission, LU (Kg NH_3/year / LU).

Table 12. Results of ammonia standard normative emissions between the 4 farms during one year including mean value estimated 95% confidence intervals (shown in square brackets) and standard variation. One livestock unit (LU) equals 500 kg animal weight.

Calculated DK norm emissions	Emission, HPU g NH3/HPU/t	Emission, animal kg NH3/year/animal	Emission, LU Kg NH3/year/LU
1. *Milther Lodahl*	1.39	13.42	12.03
2. *Søren Hansen*	1.36	15.66	12.52
3. *Jens Erik Damtoft*	1.33	11.47	11.14
4. *Knud Birch (Jersey)*	1.51	15.68	15.71
Mean year	1.40	14.06	12.85
95 % conf.	[1.32; 1.47]	[12.91;15.20]	[11.73; 13.98]
Std. variation	0.08	2.03	1.99

Data from table 12 is calculated on the basis on the Danish normative value for manure (Poulsen, 2012) and the reference emission factor of ammonia from cow stables with recirculation pit-systems for manure (Poulsen, Børsting, Rom, & Sommer, 2001). It is given that 16 % of TAN (Total Ammonia Nitrogen) is lost from these stables. TAN is calculated from the heard weight, age, race, feedstock, milk production, weight gain and growth of fetus (Lund & Aaes, 2011) Table 12 shows, that the variation between the four farms is relative small in the calculated normative ammonia emission. The variation in ammonia emission expressed in HPU is relatively smallest flowed by emission per LU and Animal. This is probably due to fact that HPU takes weight and production in to account, whereas LU only takes weight in to account.

Table 13. Data for ammonia emissions between the 4 farms during one year including mean value estimated 95% confidence intervals (shown in square brackets) and standard variation.

Average **Measured emissions**	Emission, HPU g NH_3/HPU/h	Emission, animal kg NH_3/year/animal	Emission, LU Kg NH_3/year/LU	mean indoor temp. ºC
1 *Milther Lodahl*	1.16	11.19	10.02	12.7
2 *Søren Hansen*	1.04	11.95	9.56	11.3
3 *Jens Erik Damtoft*	1.24	10.66	10.36	11.9
4 *Knud Birch (Jersey)*	1.19	12.34	12.37	11.4
Mean year **95 % conf.**	1.16 [1.08; 1.24]	11.53 [11.11; 11.96]	10.58 [9.87; 11.28]	11.8 [11.44; 12.19]
Std. variation	0.09	0.76	1.24	0.66

Table 13 shows again, that the variation between the four farms is relative small both in measured ammonia emission and temperature. The ammonia emission is between 1.08 - 1.24 g NH_3/HPU/h with 95 % probability. The measured ammonia emission is also given in 11.53 kg NH3/year/animal or 10.58 Kg NH3/year/LU.

Emission measurements from dairy cow buildings in the Netherlands shows an ammonia emissions of 14.4 kg NH_3/animal space/year (Mosquera et al., 2011).
In Germany the normative ammonia emission is 14.6 kg NH_3/animal/year for all housing types (VERA, 2011). Recent measurements from tree Danish dairy cow buildings, with recirculation pits and automated floor cleaning systems, shows an ammonia emissions of 15.2 kg NH_3/animal/year (Hansen et al., 2012). Using this ammonia emission as a reference we find a reduction of (1-(11.53/15.21))*100 = 24.2 % compared to JH acidification. According to Danish technology review for floor cleaning systems in dairy cow buildings, the effect of floor cleaning provides 25% reduction for ammonia emission (Miljøstyrelsen, AgroTech, & Niras, 2010). Danish dairy cow buildings, with recirculation pits and no floor cleaning will accordingly have an emission of 20.3 kg NH_3/animal/year and the efficiency for ammonia reduction with JH acidification will be 43.2 %.

The average indoor temperature was 11.8 ºC and the corresponding outdoor temperature was 11.0 ºC, see appendix 6, A8. The annual mean for 2011 was 9.0 ° C. It is 1.3 ° C above normal (7.7 ° C) calculated over the period 1961-90. The temperatures at the west cost of Denmark, where the farms are located, are normally 0.5 ºC warmer than the average (DMI, n.d.). The higher temperature in the test period could increase the emission the ammonia.

Table 14. Data for consumption of acid, production of slurry and calculated nitrogen loss. Mean value estimated 95% confidence intervals (shown in square brackets) and standard variations are given.

Farms	Slurry production m^3/year/animal	Total N excretion kg N/year	Total N in slurry kg N/year	N loss %	N-NH_3 loss kg/year/HPU	N-NH_3 loss kg/year/animal	N-NH_3 loss kg/year/LU
1. *Milther Lodahl*	29.3	31125	31577	-1.5	-2.1	-2.3	-2.1
2. *Søren Hansen*	34.2	36467	30869	15.4	23.7	31.3	25.0
3. *Jens Erik Damtoft*	31.2	46652	40896	12.3	17.4	17.0	16.6
4. *Knud Birch (Jersey)*	34.6	82408	70110	14.9	20.9	27.6	22.1
Mean	32.3			10.3	15.0	18.4	15.4
95 % conf.	[29.88; 34.80]				[6.60; 21.59]	[8.52; 26.93]	[6.88; 22.29]
Std. variation	2.51			5.47	11.67	15.06	12.16

Slurry production is calculated with a phosphorous balance between the concentrations of phosphorous in the slurry and the amount of excreted phosphorous. De values were controlled by level measurements in the manure tank. From the slurry production, the N concentration in the slurry and the excretion of N, the N loss can be calculated. The N loss is found to be 15.4 kg NH_3/year/LU which is bit more than the 10.58 kg NH3/year/LU measured emission, but the within the confidence interval. The standard variations for the N loss are relatively large and can partly be explained by the inhomogeneity in the slurry samples. However the results from table 14 show over all a good compliance between N loss and the measured emission. N loss is expected to me higher than emission of ammonia because nitrogen can also be lost due to denitrification.

Table 15. Consumption of sulphuric acid and production of slurry between the 4 farms. Mean value estimated 95% confidence intervals (shown in square brackets) and standard variations are given.

Farms	Acid consumption kg/year	Slurry prod. m^3/year	Acid consumption kg/m^3 slurry	Acid consumption kg/LU/year	Acid consumption kg/animal/year
1 *Milther Lodahl*	39975	7013	5.7	150	166
2 *Søren Hansen*	40212	7423	5.4	148	185
3 *Jens Erik Damtoft*	81128	12810	6.3	193	198
4 *Knud Birch (Jersey)*	102806	18734	5.5	188	190
Mean			5.7	170	185
95 % conf.			[5.50; 5.97]	[156; 183]	[177; 192]
Std. Variation			0.4	24	14

The consumption of sulphuric acid is on average 5.7 kg /m^3 slurry and between 5.50 - 5.97 kg/m^3 slurry with 95% probability.

For comparison the consumption of sulphuric acid was found to be 7.1 kg per. produced pig, which correspond to 14.8 kg/m^3 pig slurry (Pedersen & Albrechtsen, 2012).

The difference may be due to higher mean temperatures in pig slurry compared to cow slurry leading to higher mineralisation rates for pig slurry. Furthermore pig slurry, compared to cow slurry, has at higher composition of ammonia N in relation to total N. Because NH_3 is a weak base it can serve a neutralisation agent and therefore a higher acid consumption for acidification of pig slurry.

8.3 Amendments to and deviations from test plan

The test was undertaken according to the test plan except the following:

Amendments
Test staff Søren Gustav Rasmussen has replaced Peter Hansen.

The time schedule has been altered a couple of weeks due to mixing problem at farm no. 4. JH Staldservice A/S was called out to fix the problem and they changed at mixing engine and a soft starter.

The timetable has been changed for some of the test periods in order to get available the qualified test personal for the measurements.

Final timetable:

	Farm 1	**Farm 2**	**Farm 3**	**Farm 4**
Period 1_April				
Start measurement	Marts 17, 2011	Marts 25, 2011	April 4, 2011	April 12, 2011
Stop measurement	Marts 22, 2011	April 4, 2011	April 12, 2011	April 18, 2011
Period 2_June				
Start measurement	June 11, 2011	June 20, 2011	July 4, 2011	July 19, 2011
Stop measurement	June 15, 2011	June 24, 2011	July 10, 2011	July 25, 2011
Period 3_August				
Start measurement	July 30, 2011	August 16, 2011	August 23, 2011	August 29, 2011
Stop measurement	August 4, 2011	August 23, 2011	August 28, 2011	September 6, 2011
Period 4_October				
Start measurement	September 7, 2011	October 24, 2011	November 2, 2011	October 7, 2011
Stop measurement	September 11, 2011	October 28, 2011	November 6, 2011	October 13, 2011
Period 5_December				
Start measurement	December 10, 2011	December 15, 2011	December 22, 2011	December 29, 2011
Stop measurement	December 15, 2011	December 20, 2011	December 26, 2011	January 2, 2012
Period 6_February				
Start measurement	February 26, 2012	marts 6, 2012	February 15, 2012	Marts 31, 2012
Stop measurement	marts 1, 2012	marts 12, 2012	February 19, 2012	April 3, 2012

Deviations
During the first 3 measuring periods some mixing problems was experienced at farm no. 3. At the 5th and the 9th of July there was mixing failure resulting in no acidification those days. pH was still within the limits of the technology. The failure was due to a defect thermo relay.

A P P E N D I X 1

Terms and definitions used in the test plan

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 Centre for Verification of Environmental Technologies
(DANETV) Test Centre	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body
ECM	Energy corrected milk
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
HPU	Heat producing unit (one HPU = 1000 w)
Matrix	The type of material that the product is intended for
Method	Generic document that provides rules, guidelines or characteristics for tests or analysis
LU	Livestock unit (500 kg animal)
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
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis

Word	DANETV
Target	The property that is affected by the product
Test Centre, test sub-body	Sub-body of the test centre that plans and performs test
Test center, verification sub-body	Sub-body of the test centre 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
VERA	Verification of Environmental Technologies for Agricultural Production
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance
VFA	Volatile fatty acid

A P P E N D I X 2

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A P P E N D I X 3

Analysis and references methods

Slurry samples from the dairy farms where JH-FORSURING NH4+ is installed is analysed by Eurofins Danmark. Address: Smedeskovvej 38, DK-8464 Galten, Denmark. Phone: +45 7022 4266. E-mail: info@eurofins.dk.

Reference samples are analysed Analytech Miljølaboratorium A/S, Bøgildsmindevej 21, 9400 Nørresundby. From every 6 slurry samples 1 is controlled by the reference laboratory.

The different analysis and reference methods are indicated in the following table.

Analysis	D.L.	standard methods	+/-
pH	0.05	DS 287:1978	1.0%
Dry matter		DS 204:1980	3.0%
Ash fraction	1	DS 204:1980	3.0%
Ammonia-N	1	DS 224:1975	3.0%
Total-N	0.02	NP 1975:6	10%
Total-P	0.0001	ICP-OES	4.0%
Potassium	2	ICP-OES	5.0%

The reference slurry samples are shown in the table below for the 5th. measuring period. When reference data are present the average is used I all calculations.

Table A1 Reference slurry samples

Sample date: 06-01-2012 Farm	**Dry matter** %	**Total N** % of DM	**Ammonia-N** % of DM	**Total P** % of DM	**Postassium** % of DM	**pH**	**Ash** % of DM
1. Milther Lodahl	9,1	4,49	2,25	0,71	3,7	5,12	19,78
Reference	9,06	4,2	1,93	0,69	2,69	5,34	20,00
Mean	9,08	4,345	2,09	0,7	3,19	5,23	19,89
Std. Variation in % of sample	0,3	4,6	10,0	2,0	19,3	3,0	0,8
2. Søren Hansen	9,03	4,53	2,37	0,74	3,9	4,64	21,04
Reference	9,08	4,2	1,98	0,82	3,18	4,92	21,00
Mean	9,06	4,37	2,18	0,78	3,54	4,78	21,02
Std. Variation in % of sample	0,4	5,2	11,6	7,6	13,1	4,3	0,1
3. Jens Erik Damtoft	10,20	4,25	2	0,69	3,7	5,67	20,59
Reference	10,30	3,90	1,65	0,79	2,95	6,21	22,90
Mean	10,25	4,08	1,83	0,74	3,33	5,94	21,74
Std. Variation in % of sample	0,7	5,8	12,4	10,2	14,3	6,7	7,9
4. Knud Birch (80 % jersey)	6,07	5,96	3,18	0,91	4,8	4,95	26,36
Reference	6,21	5,7	2,50	1,33	4,07	5,33	26,20
Mean	6,14	5,83	2,84	1,12	4,435	5,14	26,28
Std. Variation in % of sample	1,6	3,1	15,2	32,6	10,8	5,4	0,4

A P P E N D I X   4

Analysis and methods

Test methods are described in section 3.2 Tests.

A P P E N D I X   5

Data sheet for sulphuric acid

	Produktspezifikation: Schwefelsäure 96 % (Standard I)		
PS 001	Version/Ausgabe: **4**		Seite 1 von 1
Verfasser:	**Zehl**		Datum: 19.05.2004
Geprüft und freigegeben:	**Zehl**		Datum: 19.05.2004

Produktbezeichnung:	**Schwefelsäure 96 %**
Konzentration:	**ca. 96 % H_2SO_4 (95 % - 97 %)**
Farbe:	**Apha Hazen <40**

Gemäß Kundenvorschrift/Produktspezifikation

Nr. vom:

	ppm
Hg	<0,3
Fe	<30
Pb	<0,6
Zn	<0,3
Cr	<0,5
Ni	<0,6
Cu	<0,3
As	<0,03
Se	<0,01
Cl	<0,5

Bemerkungen: Weitere Elemente auf Anfrage
Zertifikate nach DIN EN 10204-2.2 nach Vereinbarung
Zertifizierung nach DIN EN ISO 9002 / 2000
EG-Sicherheitsdatenblatt gemäß 91/155/EWG

Verteiler:

ZEN-SB (Original)
ZEN-R (BL, BI, HAM)
Aushang/Ordner: MW-WO, MW- ABA
XZG-V, XZG-T, SUC-LO

Ausdruck bitte auf Aktualität prüfen — Druckdatum und Uhrzeit: 03.06.04 13:52

A P P E N D I X   6

Test data report

Table A2. Sample data from 1. measurement period.

Farms **Sample period**	**1. *Milther Lodahl*** ***17/3/11 - 22/3/11***	**2. *Søren Hansen*** ***25/3/11 - 4/4/11***	**3. *Jens Erik Damtoft*** ***4/4/11 - 12/4/11***	**4. *Knud Birch (jersey)*** ***12/4/11 - 18/4/11***
Cows	155	217	180	566
Cows in dry period	17	0	18	0
Heifers	30	0	90	0
Animals	202	217	288	566
LU (livestock units)	237	271	314	572
HPU (heat producing units)	241	304	305	677
Milk production, kg ECM/cow/day	30.3	31.8	28.9	28.5
Milk production, kg /cow/day	28.8	30	27.2	22.9
Protein in milk, %	3.33	3.37	3.39	3.92
Dry matter in feedstock, kg/day/cow	20.4	22.8	19.8	19.8
Protein in feedstock, %/DM	18.4	16.6	16.9	18
N excretion, kg N/year/cow	162.4	161.4	141.4	155.4
TAN excretion, kg urea-N/year/cow	86.2	71.3	69.0	82.9
Total N excretion, kg N/year	28509	35018	31902	87932
Total TAN excretion, kg urea-N/year	15218	15480	16340	46905
Norm. , kg N/year	25254	30684	31897	80032
Norm. TAN excretion, kg urea-N/year	12042	14257	15745	37186
Phosphorus in feedstock, g P/day/cow	105	92	84	82
Phosphorus excretion, kg P/year/cow	27.0	22.0	20.0	19.6
Total phosphorus excretion, kg P/year	4707	4764	4459	11096
Slurry sample date	***03-06-2011***	***04-04-2011***	***12-04-2011***	***19-04-2011***
Phosphorus concentration in slurry g P/l	0.73	0.58	0.77	0.49
Nitrogen concentration in slurry g N/l	4.81	3.74	4.52	3.30
Slurry production m^3/year	6425	8168	5783	22453
Slurry production m^3/year/LU	27.1	30.1	18.4	39.3
Total nitrogen in slurry, kg N/year	30912	30566	26127	74027
Dry matter (DM) in slurry, %	9.90	8.10	10.86	7.06
Ammonia nitrogen in slurry, % of DM	2.66	2.38	2.22	2.29
Potassium concentration, % of DM	3.6	4.1	3.5	3.5
pH in slurry	5.53	5.26	5.27	5.84
Ash fraction, % of DM	21.21	20.99	20.26	18.41
NH_3 emission/HPU, g NH_3/HPU/t	1.0144	0.7699	1.0018	0.8123
NH_3 emission/animal, kg NH_3/year/animal	10.61	9.44	9.30	8.52
NH_3 emission/LU, Kg NH_3/year/LU	9.04	7.55	8.54	8.43
Total NH_3-N emission, kg N/year	1765	1687	2206	3969
N emission in % of N excretion	6.2	4.8	6.9	4.5
N emission in % of TAN excretion	11.6	10.9	13.5	8.5
Mean indoor temp, ºC	7.1	8.9	10.0	11.0
Mean outdoor temp, ºC	5.9	7.7	10.1	8.5
Mean wind direction, °	257.5	224.6	227.2	276.3
Mean wind speed, m/s	3.2	4.9	5.5	4.8
Mean relative humidity, RH	87.7	81.2	83.2	77.5
[H_2S] , ppb	BLD	BLD	BLD	BLD
[CH_4] , ppm	5.84	12.72	3.89	12.42
[N_2O] , ppm	0.44	0.38	0.44	0.44
[CO_2] , ppm	566	638	528	638

Table A3 Sample data from 2. measurement period.

Farms **Sample period**	**1. *Milther Lodahl*** ***11/6/11 - 15/6/11***	**2. *Søren Hansen*** ***20/6/11 - 24/6/11***	**3. *Jens Erik Damtoft*** ***4/7/11 - 10/7/11***	**4. *Knud Birch (jersey)*** ***19/7/11 - 25/7/11***
Cows	155	215	207	531
Cows in dry period	17	0	26	0
Heifers	30	0	175	0
Animals	202	215	408	531
LU (livestock units)	237	269	420	536
HPU (heat producing units)	241	290	398	628
Milk production, kg ECM/cow/day	30.3	29.4	29.4	27.9
Milk production, kg /cow/day	28.8	27	27.6	22.1
Protein in milk, %	3.33	3.37	3.36	3.87
Dry matter in feedstock, kg/day/cow	20.4	22.3	20.9	19.5
Protein in feedstock, %/DM	18.4	17	16.9	17.8
N excretion, kg N/year/cow	162.4	168.1	151.8	152.7
TAN excretion, kg urea-N/year/cow	86.2	80.6	73.0	81.8
Total N excretion, kg N/year	28509	36143	42981	81071
Total TAN excretion, kg urea-N/year	15218	17337	22289	43447
Norm. , kg N/year	25254	30401	40829	75083
Norm. TAN excretion, kg urea-N/year	12042	14126	20768	34887
Phosphorus in feedstock, g P/day/cow	103	92	85	82
Phosphorus excretion, kg P/year/cow	26.3	22.9	20.1	20.1
Total phosphorus excretion, kg P/year	4587	4930	5704	10694
Slurry sample date	***29-07-2011***	***20-06-2011***	***04-07-2011***	***15-07-2011***
Phosphorus concentration in slurry g P/l	0.71	0.61	0.17	0.59
Nitrogen concentration in slurry g N/l	4.54	4.09	1.93	3.97
Slurry production m^3/year	6452	8040	33953	18064
Slurry production m^3/year/LU	27.2	29.9	80.9	33.7
Total nitrogen in slurry, kg N/year	29266	32891	65526	71680
Dry matter (DM) in slurry, %	9.00	8.76	2.10	8.00
Ammonia nitrogen in slurry, % of DM	2.84	2.35	6.24	2.68
Potassium concentration, % of DM	3.7	4.1	12	3.8
pH in slurry	5.68	5.12	6.69	5.96
Ash fraction, % of DM	21.11	20.55	45.71	18.75
NH_3 emission/HPU, g NH_3/HPU/t	1.4588	1.1761	1.4	1.1506
NH_3 emission/animal, kg NH_3/year/animal	15.25	13.88	11.98	11.93
NH_3 emission/LU, Kg NH_3/year/LU	13.00	11.10	11.64	11.81
Total NH_3-N emission, kg N/year	2538	2457	4025	5217
N emission in % of N excretion	8.9	6.8	9.4	6.4
N emission in % of TAN excretion	16.7	14.2	18.1	12.0
Mean indoor temp, ºC	21.8	16.2	18.6	17.4
Mean outdoor temp, ºC	15.3	15.9	17	16.5
Mean wind direction, °	242.6	249.4	182	228
Mean wind speed, m/s	2.5	4.8	2.6	2.8
Mean relative humidity, RH	75.8	78.8	82.2	84
[H_2S] , ppb	BLD	130	BLD	BLD
[CH_4] , ppm	15.41	25.89	19.90	24.39
[N_2O] , ppm	0.22	0.22	0.22	0.22
[CO_2] , ppm	584	667	588	614

Table A4 Sample data from 3. measurement period.

Farms Sample period	1. Milther Lodahl 30/7/11 - 4/8/11	2. Søren Hansen 16/8/11 - 23/8/11	3. Jens Erik Damtoft 23/8/11 - 28/8/11	4. Knud Birch (jersey) 29/8/11 - 6/9/11
Cows	154	215	210	534
Cows in dry period	17	0	28	0
Heifers	84	0	193	0
Animals	255	215	431	534
LU (livestock units)	275	269	439	539
HPU (heat producing units)	267	278	414	621
Milk production, kg ECM/cow/day	29.15	26.9	29.4	27
Milk production, kg /cow/day	28.4	25.2	27.6	21.2
Protein in milk, %	3.33	3.37	3.49	3.87
Dry matter in feedstock, kg/day/cow	20.4	22.2	21.3	19.5
Protein in feedstock, %/DM	18.4	16.8	16.8	17.8
N excretion, kg N/year/cow	163.2	167.2	152.1	154.7
TAN excretion, kg urea-N/year/cow	87.0	81.0	71.2	83.8
Total N excretion, kg N/year	31164	35957	44611	82593
Total TAN excretion, kg urea-N/year	17058	17409	22824	44756
Norm. , kg N/year	27812	30401	42369	75508
Norm. TAN excretion, kg urea-N/year	13785	14126	21668	35084
Phosphorus in feedstock, g P/day/cow	104	93	86	82
Phosphorus excretion, kg P/year/cow	26.8	24.0	20.5	20.5
Total phosphorus excretion, kg P/year	4999	5156	6007	10934
Slurry sample date	*11-08-2011*	*23-08-2011*	*28-08-2011*	*29-08-2011*
Phosphorus concentration in slurry g P/l	0.70	0.67	0.64	0.58
Nitrogen concentration in slurry g N/l	4.56	4.38	3.86	3.88
Slurry production m^3/year	7116	7681	9340	18710
Slurry production m^3/year/LU	25.8	28.6	21.3	34.7
Total nitrogen in slurry, kg N/year	32428	33620	36040	72565
Dry matter (DM) in slurry, %	8.78	7.14	8.81	7.59
Ammonia nitrogen in slurry, % of DM	3.28	3.42	2.5	2.87
Potassium concentration, % of DM	3.8	4.8	4.5	3.6
pH in slurry	5.31	4.75	5.38	5.27
Ash fraction, % of DM	21.64	26.61	22.70	22.40
NH_3 emission/HPU, g NH_3/HPU/t	1.2574	1.1127	1.6766	1.8831
NH_3 emission/animal, kg NH_3/year/animal	11.54	12.59	14.12	19.20
NH_3 emission/LU, Kg NH_3/year/LU	10.69	10.07	13.86	19.01
Total NH_3-N emission, kg N/year	2424	2229	5012	8442
N emission in % of N excretion	7.8	6.2	11.2	10.2
N emission in % of TAN excretion	14.2	12.8	22.0	18.9
Mean indoor temp, ºC	19.8	17.8	18.1	16
Mean outdoor temp, ºC	18.1	15.5	17.6	15.5
Mean wind direction, °	229.8	124.1	136.2	223.8
Mean wind speed, m/s	2.5	2.6	2.3	4.5
Mean relative humidity, RH	80.7	82.4	90.1	84.9
[H_2S] , ppb	BLD	BLD	BLD	BLD
[CH_4] , ppm	21.40	30.82	21.55	20.20
[N_2O] , ppm	0.22	0.22	0.22	0.22
[CO_2] , ppm	588	762	586	584

Table A5 Sample data from 4. measurement period.

Farms Sample period	1. Milther Lodahl 7/9/11 -11/9/11	2. Søren Hansen 24/10/11 - 28/10/11	3. Jens Erik Damtoft 2/11/11 - 6/11/11	4. Knud Birch (jersy) 7/10/11 - 13/10/11
Cows	157	213	215	540
Cows in dry period	22	0	31	0
Heifers	84	0	195	0
Animals	263	213	441	540
LU (livestock units)	285	266	451	545
HPU (heat producing units)	271	271	422	646
Milk production, kg ECM/cow/day	28	26	28.9	28.5
Milk production, kg /cow/day	26.1	24.9	28	23.2
Protein in milk, %	3.43	3.58	3.51	3.99
Dry matter in feedstock, kg/day/cow	20.4	22.8	22.6	19.6
Protein in feedstock, %/DM	17.5	16.7	17.65	17.8
N excretion, kg N/year/cow	155.3	169.7	175.0	149.7
TAN excretion, kg urea-N/year/cow	79.6	79.5	85.6	78.3
Total N excretion, kg N/year	30965	36156	50730	80831
Total TAN excretion, kg urea-N/year	16409	16938	26497	42262
Norm. , kg N/year	28777	30118	43500	76356
Norm. TAN excretion, kg urea-N/year	14233	13994	22214	35478
Phosphorus in feedstock, g P/day/cow	102	93	89	81
Phosphorus excretion, kg P/year/cow	26.9	24.1	21.5	19.4
Total phosphorus excretion, kg P/year	5188	5125	6398	10449
Slurry sample date	03-10-2011	03-10-2011	01-11-2011	20-10-2011
Phosphorus concentration in slurry g P/l	0.70	0.63	0.65	0.54
Nitrogen concentration in slurry g N/l	4.48	4.00	3.81	3.65
Slurry production m^3/year	7436	8171	9902	19392
Slurry production m^3/year/LU	26.1	30.7	22.0	35.6
Total nitrogen in slurry, kg N/year	33314	32669	37756	70807
Dry matter (DM) in slurry, %	9.18	8.71	9.1	7.09
Ammonia nitrogen in slurry, % of DM	2.71	2.41	2.3	2.83
Potassium concentration, % of DM	3.8	3.5	4.2	3.80
pH in slurry	5.41	5.16	6.51	6.35
Ash fraction, % of DM	20.70	20.67	20.88	21.16
NH_3 emission/HPU, g NH_3/HPU/t	1.3923	0.9829	1.0243	1.3544
NH_3 emission/animal, kg NH_3/year/animal	12.56	10.95	8.59	14.20
NH_3 emission/LU, Kg NH_3/year/LU	11.57	8.76	8.40	14.06
Total NH_3-N emission, kg N/year	2719	1921	3118	6314
N emission in % of N excretion	8.8	5.3	6.1	7.8
N emission in % of TAN excretion	16.6	11.3	11.8	14.9
Mean indoor temp, ºC	15	13.8	11	10.7
Mean outdoor temp, ºC	14.4	13.8	10.1	9.3
Mean wind direction, °	233.8	251.7	124.7	230
Mean wind speed, m/s	3	5.9	7.7	4.8
Mean relative humidity, RH	91.4	88	96.2	80.9
[H_2S] , ppb	BLD	BLD	BLD	BLD
[CH_4] , ppm	15.56	18.70	15.41	12.72
[N_2O] , ppm	0.27	0.22	0.27	0.27
[CO_2] , ppm	555	592	627	552

Table A6 Sample data from 5. measurement period.

Farms Sample period	1. *Milther Lodahl* *10/12/11 - 15/12/11*	2. *Søren Hansen* *15/12/11 - 20/12/11*	3. *Jens Erik Damtoft* *22/12/11 - 26/12/11*	4. *Knud Birch (jersey)* *29/12/11 - 2/1/12*
Cows	157	223	222	533
Cows in dry period	22	0	18	0
Heifers	82	0	199	0
Animals	261	223	439	533
LU (livestock units)	284	279	446	538
HPU (heat producing units)	276	292	433	639
Milk production, kg ECM/cow/day	29.9	27.6	30.6	28.6
Milk production, kg /cow/day	27.2	25.8	28.4	24.2
Protein in milk, %	3.43	3.5	3.43	4.07
Dry matter in feedstock, kg/day/cow	20.4	21.7	23.9	19.7
Protein in feedstock, %/DM	18	17.4	18.5	17.7
N excretion, kg N/year/cow	159.1	166.8	200.8	146.2
TAN excretion, kg urea-N/year/cow	83.1	83.4	102.5	74.2
Total N excretion, kg N/year	31460	37202	56469	77917
Total TAN excretion, kg urea-N/year	16900	18588	30324	39568
Norm. , kg N/year	28677	31532	43286	75366
Norm. TAN excretion, kg urea-N/year	14166	14651	22156	35018
Phosphorus in feedstock, g P/day/cow	99	88	93	83
Phosphorus excretion, kg P/year/cow	25.4	22.1	22.8	19.5
Total phosphorus excretion, kg P/year	4926	4918	6684	10385
Slurry sample date	***03-10-2011***	***03-10-2011***	***01-11-2011***	***20-10-2011***
Phosphorus concentration in slurry g P/l	0.64	0.71	0.76	0.69
Nitrogen concentration in slurry g N/l	3.95	3.95	4.18	3.58
Slurry production m^3/year	7749	6963	8813	15101
Slurry production m^3/year/LU	27.3	25.0	19.8	28.1
Total nitrogen in slurry, kg N/year	30574	27520	36809	54056
Dry matter (DM) in slurry, %	9.08	9.055	10.25	6.14
Ammonia nitrogen in slurry, % of DM	2.09	2.18	1.83	2.84
Potassium concentration, % of DM	3.20	3.54	3.33	4.44
pH in slurry	5.23	4.78	5.94	5.14
Ash fraction, % of DM	19.89	21.02	21.74	26.28
NH3 emission/HPU, g NH_3/HPU/t	0.9885	0.9896	1.1872	1.1631
NH3 emission/animal, kg NH_3/year/animal	9.16	11.33	10.25	12.22
NH3 emission/LU, Kg NH_3/year/LU	8.42	9.07	10.09	12.10
Total NH_3-N emission, kg N/year	1969	2081	3707	5362
N emission in % of N excretion	6.3	5.6	6.6	6.9
N emission in % of TAN excretion	11.7	11.2	12.2	13.6
Mean indoor temp, ºC	5.4	4.6	7.9	6.6
Mean outdoor temp, ºC	4.7	3	7.3	5.8
Mean wind direction, °	224.4	234.1	208.7	241.3
Mean wind speed, m/s	5.1	3.8	5	18.1
Mean relative humidity, RH	97.2	91	97.4	91.2
[H_2S] , ppb	BLD	BLD	BLD	BLD
[CH_4] , ppm	9.43	17.36	9.88	15.11
[N_2O] , ppm	0.33	0.27	0.33	0.33
[CO_2] , ppm	555	662	546	613

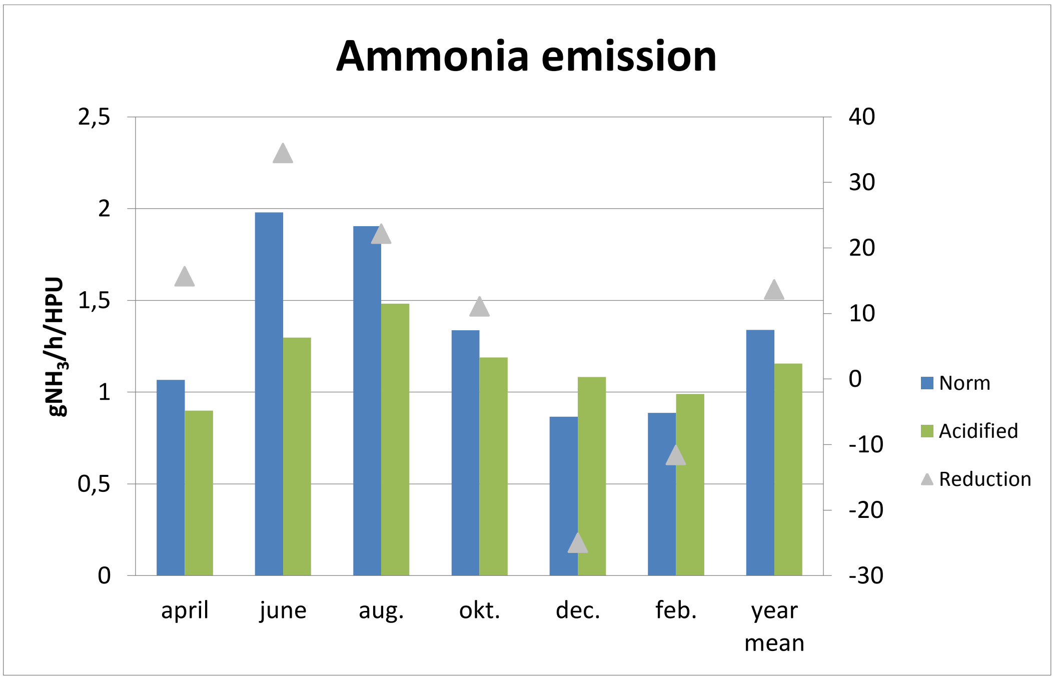
Table A7 Sample data from 6. measurement period.

Farms Sample period	1. *Milther Lodahl* *26/2/12 - 1/3/12*	2. *Søren Hansen* *6/3/12 - 12/3/12*	3. *Jens Erik Damtoft* *15/2/12 - 19/2/12*	4. *Knud Birch (jersey)* *31/3/12 - 3/4/12*
Cows	160	221	225	541
Cows in dry period	18	0	18	0
Heifers	84	0	212	0
Animals	262	221	455	541
LU (livestock units)	284	276	459	546
HPU (heat producing units)	280	287	434	647
Milk production, kg ECM/cow/day	30.4	27.3	28.5	28.5
Milk production, kg /cow/day	28.8	27.3	27.5	23.2
Protein in milk, %	3.47	3.51	3.45	3.98
Dry matter in feedstock, kg/day/cow	23.7	22.0	23.3	19.7
Protein in feedstock, %/DM	17.8	17.9	17.4	18.2
N excretion, kg N/year/cow	187.5	173.4	180.8	155.5
TAN excretion, kg urea-N/year/cow	90.9	87.7	87.0	83.3
Total N excretion, kg N/year	36144	38325	53222	84105
Total TAN excretion, kg urea-N/year	18263	19375	27588	45055
Norm. , kg N/year	28769	31249	44360	76497
Norm. TAN excretion, kg urea-N/year	14230	14520	22788	35544
Phosphorus in feedstock, g P/day/cow	98	89	93	84
Phosphorus excretion, kg P/year/cow	24.4	21.6	23.2	20.5
Total phosphorus excretion, kg P/year	4784	4783	6914	11075
Slurry sample date	***19-04-2012***	***17-04-2012***	***17-04-2012***	***30-03-2012***
Phosphorus concentration in slurry g P/l	0.69	0.87	0.76	0.59
Nitrogen concentration in slurry g N/l	4.78	5.07	4.75	4.15
Slurry production m^3/year	6899	5515	9068	18683
Slurry production m^3/year/LU	24.3	20.0	19.7	34.2
Total nitrogen in slurry, kg N/year	32970	27946	43118	77526
Dry matter (DM) in slurry, %	9.37	12.39	10.59	9.12
Ammonia nitrogen in slurry, % of DM	2.87	1.61	2.35	2.43
Potassium concentration, % of DM	4.1	2.5	3.7	3.2
pH in slurry	5.52	2	6.51	5.83
Ash fraction, % of DM	20.28	20.18	21.72	17.54
NH_3 emission/HPU, g NH_3/HPU/t	0.8541	1.1865	1.1535	0.7628
NH_3 emission/animal, kg NH_3/year/animal	8.01	13.52	9.64	8.00
NH_3 emission/LU, Kg NH_3/year/LU	7.38	10.81	9.55	7.92
Total NH_3-N emission, kg N/year	1727	2460	3613	3563
N emission in % of N excretion	4.8	6.4	6.8	4.2
N emission in % of TAN excretion	9.5	12.7	13.1	7.9
Mean indoor temp, ºC	7.2	6.3	5.9	6.5
Mean outdoor temp, ºC	7.1	5.4	3.8	4.8
Mean wind direction, °	267.1	243.4	211.9	237.5
Mean wind speed, m/s	2.3	6.6	5	11.5
Mean relative humidity, RH	94.4	90.4	94.5	68
[H_2S] , ppb	BLD	BLD	BLD	BLD
[CH_4] , ppm	6.88	12.72	14.21	12.72
[N_2O] , ppm	0.33	0.33	0.33	0.33
[CO_2] , ppm	521	599	634	605

Table A8 Mean sample data from one year.

Farms Sample period	1. *Milther Lodahl* *17/3/11 - 3/4/12*	2. *Søren Hansen* *17/3/11 - 3/4/12*	3. *Jens Erik Damtoft* *17/3/11 - 3/4/12*	4. *Knud Birch (jersey)* *17/3/11 - 3/4/12*	Mean *17/3/11 - 3/4/12*
Cows	156	217	210	541	281
Cows in dry period	19	0	23	0	11
Heifers	66	0	177	0	61
Animals	241	217	410	541	352
LU (livestock units)	267	272	421	546	377
HPU (heat producing units)	263	287	401	643	399
Milk production, kg ECM/cow/day	29.68	28.17	29.28	28.17	29
Milk production, kg /cow/day	28.02	26.70	27.72	22.80	26
Protein in milk, %	3.39	3.45	3.44	3.95	4
Dry matter in feedstock, kg/day/cow	20.93	22.30	21.98	19.63	21
Protein in feedstock, %/DM	18.08	17.07	17.36	17.88	18
N excretion, kg N/year/cow	164.99	167.78	166.98	152.34	163.0
TAN excretion, kg urea-N/year/cow	85.49	80.58	81.40	80.71	82
Total N excretion, kg N/year	31125	36467	46652	82408	49163
Total TAN excretion, kg urea-N/year	16511	17521	24310	43665	25502
Norm. , kg N/year	27424	30731	41040	76474	43917
Norm. TAN excretion, kg urea-N/year	13416	14279	20890	35533	21029
Phosphorus in feedstock, g P/day/cow	102	91	88	82	91
Phosphorus excretion, kg P/year/cow	26.13	22.77	21.33	19.92	23
Total phosphorus excretion, kg P/year	4865	4946	6028	10772	6653
Slurry sample date	***17/3/11 - 3/4/12***	***17/3/11 - 3/4/12***	***17/3/11 - 3/4/12***	***17/3/11 - 3/4/12***	
Phosphorus concentration in slurry g P/l	0.70	0.68	0.62	0.58	0.65
Nitrogen concentration in slurry g N/l	4.52	4.20	3.84	3.75	4.08
Slurry production m^3/year	7013	7423	12810	18734	11495
Slurry production m^3/year/LU	26.30	27.37	30.35	34.24	29.6
Total nitrogen in slurry, kg N/year	31577	30869	40896	70110	43363
Dry matter (DM) in slurry, %	9.22	9.03	8.62	8	8.59
Ammonia nitrogen in slurry, % of DM	2.74	2.39	2.91	3	2.67
Potassium concentration, % of DM	3.70	3.76	5.20	4	4.10
pH in slurry	5.45	4.51	6.05	6	5.44
Ash fraction, % of DM	20.80	21.67	25.50	21	22.18
NH_3 emission/HPU, g NH_3/HPU/t	1.161	1.036	1.241	1.188	1.1564
NH_3 emission/animal, kg NH_3/year/animal	11.19	11.95	10.65	12.34	11.53
NH_3 emission/LU, Kg NH_3/year/LU	10.02	9.56	10.35	12.22	10.54
Total NH_3-N emission, kg N/year	2190	2139	3613	5478	3355
N emission in % of N excretion	7.0	5.9	7.7	6.6	6.82
N emission in % of TAN excretion	13.3	12.2	14.9	12.5	13.22
Mean indoor temp, ºC	12.7	11.3	11.9	11.4	11.8
Mean outdoor temp, ºC	10.9	10.2	11.0	10.1	11
Mean wind direction, °	242.5	221.2	181.8	239.5	221
Mean wind speed, m/s	3.1	4.8	4.7	7.8	5
Mean relative humidity, RH	87.9	85.3	90.6	81.1	86
[H_2S] , ppb	BLD	22	BLD	BLD	5.5
[CH_4] , ppm	12.4	19.7	14.1	16.3	15.6
[N_2O] , ppm	0.3	0.3	0.3	0.3	0.29
[CO_2] , ppm	561.6	653.5	584.9	601.0	600

Figure A9 Emissions of ammonia from an acidified and a normalized dairy farm and the reduction in %. The values given are and average of the 4 different farms.



As expected the ammonia emission is higher in the summer period than in the winter period due to temperature effects. Normtiv values of ammonia emission is estimated with an empirical model that calculate the temperature effect.

Figure A10 Emissions of ammonia from an acidified, normalized dairy farm and from a normalized dairy farm corrected for feeding and milk production. The values given are and average of the 4 different farms in the 6 periods.

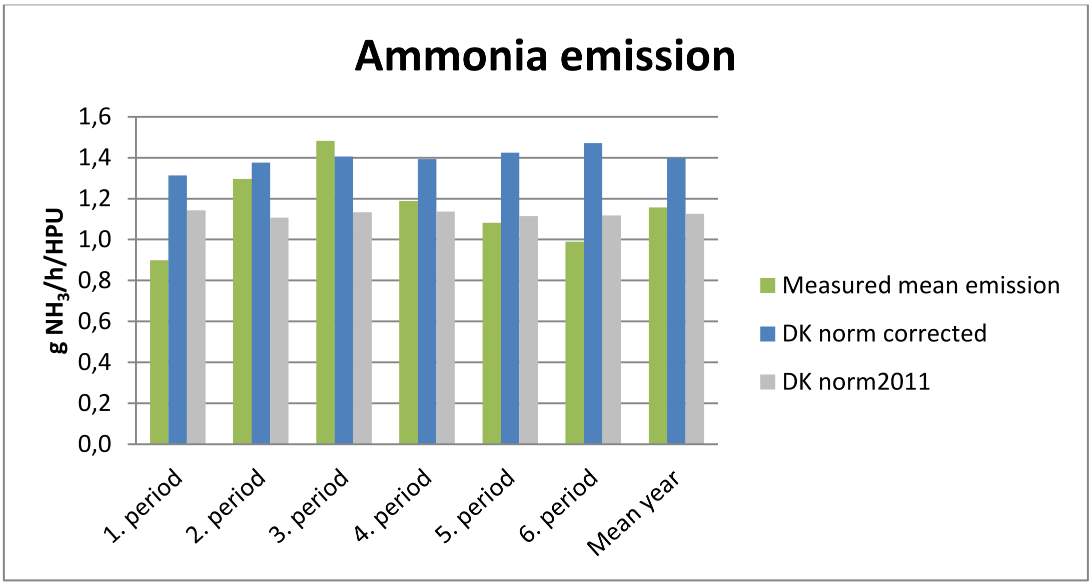
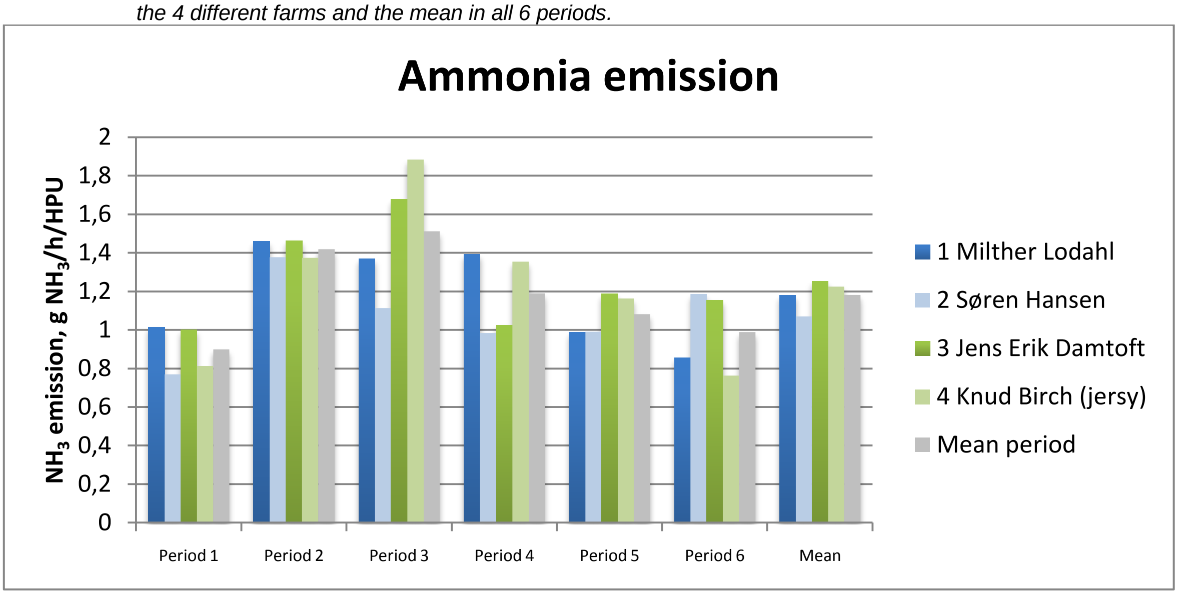


Figure A11 Emissions of ammonia from the acidified and normalized dairy farms. The values are given for the 4 different farms and the mean in all 6 periods.



A P P E N D I X 7

Amendment and deviation reports for test

The test was undertaken according to the test plan except the flowering:

Amendments
Test staff Søren Gustav Rasmussen has replaced Peter Hansen.

The time schedule have been altered a couple of weeks due to mixing problem at farm no. 4. JH Staldservice A/S was called out to fix the problem and they changed at mixing engine and a soft starter.

The timetable has been changed for some of the test periods in order to get available the qualified test personal for the measurements.

Table 16. Final test schedule.

Task/md-year	mar-11	apr-11	may-11	jun-11	jul-11	aug-11	sep-11	okt-11	nov-11	dec-11	jan-12	feb-12	dec-12	Jan-13
Test plan	x													
Installation and pre-testing	x													
Start test periode (7.marts.2011)	x													
Sampling periode		x		x		x		x		x		x		
End of test period (20.feb.2012)												x		
Test report draft							x						x	
Test report quality assurance													x	
Test report final version														x

Table 17. *Final timetable.*

	Farm 1	**Farm 2**	**Farm 3**	**Farm 4**
Period 1_April				
Start measurement	Marts 17, 2011	Marts 25, 2011	April 4, 2011	April 12, 2011
Stop measurement	Marts 22, 2011	April 4, 2011	April 12, 2011	April 18, 2011
Period 2_June				
Start measurement	June 11, 2011	June 20, 2011	July 4, 2011	July 19, 2011
Stop measurement	June 15, 2011	June 24, 2011	July 10, 2011	July 25, 2011
Period 3_August				
Start measurement	July 30, 2011	August 16, 2011	August 23, 2011	August 29, 2011
Stop measurement	August 4, 2011	August 23, 2011	August 28, 2011	September 6, 2011
Period 4_October				
Start measurement	September 7, 2011	October 24, 2011	November 2, 2011	October 7, 2011
Stop measurement	September 11, 2011	October 28, 2011	November 6, 2011	October 13, 2011
Period 5_December				
Start measurement	December 10, 2011	December 15, 2011	December 22, 2011	December 29, 2011
Stop measurement	December 15, 2011	December 20, 2011	December 26, 2011	January 2, 2012
Period 6_February				
Start measurement	February 26, 2012	marts 6, 2012	February 15, 2012	Marts 31, 2012
Stop measurement	marts 1, 2012	marts 12, 2012	February 19, 2012	April 3, 2012

Deviations

During the first 3 measuring periods some mixing problems was experienced at farm no. 3. At the 5th and the 9th of July there was mixing failure resulting in no acidification those days. pH was still in within the limits of the technology. The failure was due to a defect thermo relay.

A P P E N D I X   8

User manual

2010

Jørgen Hyldgård Staldservice A/S

[JH-FORSURING NH4+]

EGENKONTROL & SIKKERHED

Egenkontrol af JH-gylleforsuringsanlæg NH4+ fra Jørgen Hyldgård Staldservice A/S.

Mindske risiko for påkørsel og syre udslip i grundvand/fjord.

Fornuftig placering af syretank.

Hævet fundament med en 10x10 cm kant og afløb til gyllekanal.

Pullerter foran tank.

Syretank dobbeltskroget med skueglas.

Kompressor med tørrepatron for at undgå tæring af tank.

Syreafgang i top af tank.

Aflåst styre skab og syretank.

Daglig og løbende kontrol

Kontrol af pH værdier og syreforbrug i de enkelte staldafsnit dagligt.

Restmængde i syretank.

Eventuelle alarmer til mail eller på sms.

Check skueglas.

Service af anlæg.

Service eftersyn hver 6 måned:

- Kalibrering af begge pH målere.
- Kontrol af syrepumpe, kompressor herunder adsorptionsfilter, niveau måler samt automatisk overpumpnings stop.

I brugervejledningen, medfølger en oversigt over service der udføres.

Påfyldning af syre, sikring imod uheld.

Syrelevering skal ske med godkendte syretransporter, og uddannede chauffører (ADAC)

Overpumpning til syretank skal ske med vacuum-system som sikrer mod dråbetab.

Rindende vand til rådighed under påfyldning, samt nødbruse system og øjenskylle-hane, som sikrer rindende vand i frostvejr.

Stigeglas holdes under opsyn for at forhindre overfyldning af syretank.

Opstart af anlægget samt indkøring.

Anlægget opstartes med gradvis øget tilsætning af svovlsyre under opsyn af montør.

Der måles for evt. svovlbrinte fare.

Anlægget er 100% funktions dygtig, 1-2 måneder efter stalden er i fuld drift.

Alarmer ved ikke korrekt funktion.

Høj - lav pH.

Fejl i lagertank overvågning.

Driftsstop / nødstop.

Stor difference mellem pH-elektroder.

Lav syrestand i tank.

Kompressorfejl.

For-/lagertank fuld.

Omrører stoppet.

Ved korrekt funktion.

Daglig måling af pH og syreforbrug med logninger til hjemmeside.

Overvågning via mobiltelefon samt internet.

Dokumentation.

PC styring af logning af pH, alarmer, kundenavn samt dato.

Aflæsninger kan kontrolleres på hjemmeside.

Data gemmes i min. 5 år.

Leverandørbrugsanvisning for koncentreret svovlsyre.

Arbejdspladsbrugsanvisning.