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Environmental Testing of DANETV Products

Field study report
NH4+ Slurry Acidification System

Ver. 1

DELTA 2011

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DANish Environmental Technology Verification

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The Danish Centre for Verification of Climate and Environmental Technologies, DANETV, offers independent tests of technologies and products for the reduction of climate and environmental changes and of monitoring equipment detecting environmental changes. The focus is on technologies that are of great importance to the progress of climate and environmental strategy and also on the positioning of Danish suppliers of innovative technologies. DANETV is a co-operation between five technological service institutes: DHI, Danish Technological Institute, FORCE Technology, DELTA and AgroTech. DANETV has been established with financial support from the Danish Ministry of Science, Technology and Innovation.

Table of contents

Summary

This document is describing the field study of a NH4+ Slurry Acidification System performed as a part of the DELTA activities in the DANETV project for 2011.

The main purpose of the field study was to evaluate the long term robustness of the system seen from DELTA's point of view. But it is also the intention to use this field study used as a more general case in the DANETV project.

The results of the field study can be summarised as follows:

- Detailed robustness evaluation and recommendations were given directly to the representative from the equipment manufacturer present during the field study.
- Overall reliability recommendations are given in annex 1 of the report.
- It has been confirmed that the environmental conditions for this kind of equipment are very harsh. And that special care during design and construction must be made in order to ensure high robustness.

The results from this field study can be further used to make the following 2 documents:

- A proposal for an environmental test specification for this kind of equipment/application.
- A proposal for a set of accelerated test specifications for the critical parts of the system.

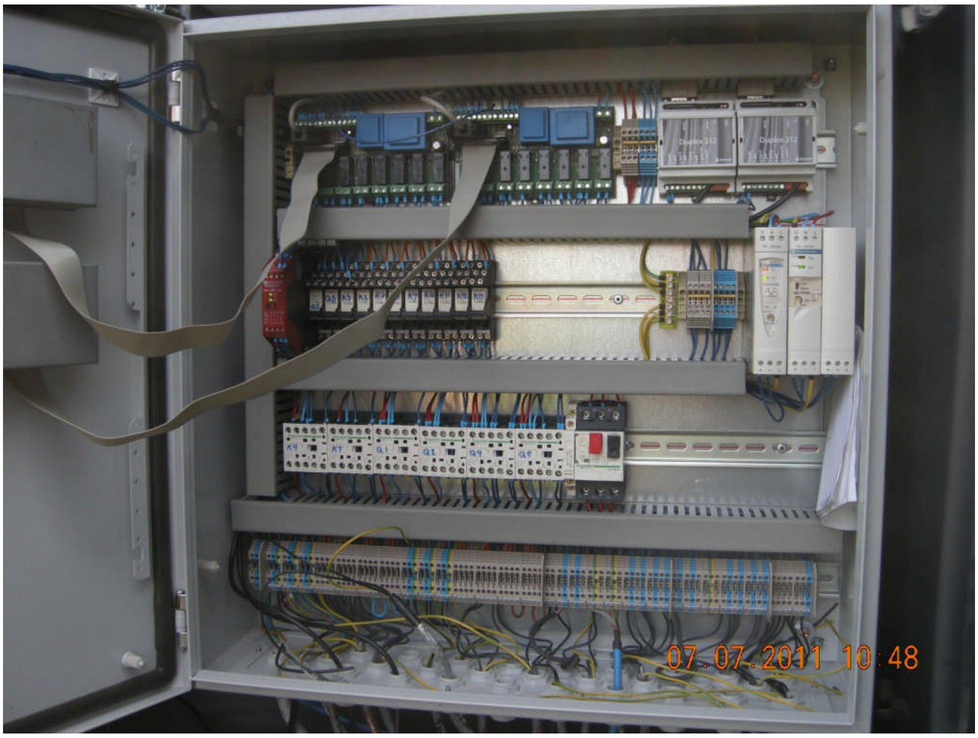
Field study data

What:
NH4+ Slurry Acidification System manufactured by Jørgen Hyldgaard Staldservice A/S. The system has been in operation for less than 1 year. See photos of main system components below:

Acid tank

Acid tank and control cabinet

Inside control cabinet

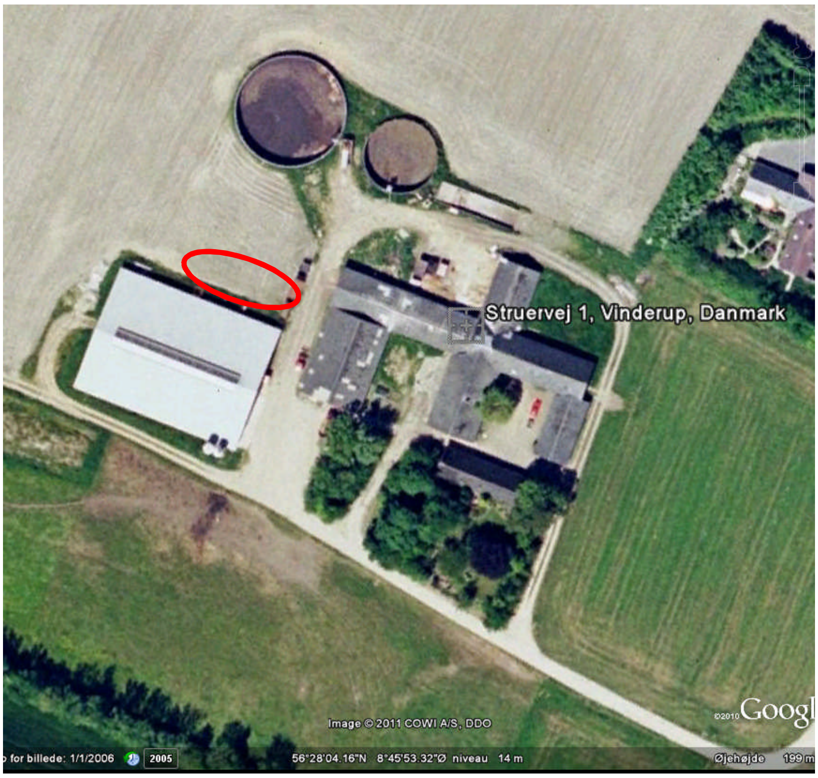


Inside cabinet for electronics

Cabinet with pH electronics on top of slurry tank

Top of slurry tank

Where:
Cattle Farm at Struervej1, 7830 Vinderup, Denmark, see figures below:



Who:
The following persons where present during the field study:

From Agrotech:

Thorkild Quist Frandsen, Linda Veggerbo and Amparo Gómez Cortina

From Jørgen Hyldgaard Staldservice A/S:

Henrik Ibsen

From DELTA:

Anders B. Kentved and Kim A. Schmidt

When:

2011-07-07, 10:30 - 12:30

How:

The inspection was performed as a visual inspection of the systems main components. The system was running in normal operational mode as a part of the overall Agrotech performance verification (this is not described in this document).

Purpose of the field study

The main purpose of the field study was to evaluate the long term robustness of the system seen from DELTA's point of view.

But it is also the intention to use this field study used as a more general case in the DANETV project.

Agrotech has raised the following questions before the field study:

a. Can possible degradation of the system performance over time be evaluated?

b. Does the system have weak points that can be expected to give problems?

c. How will these kind of problems show and when will they occur?

d. Can something be done in order to prevent these problems to occur?

And as possible focus areas could be:

1. Are the electrical installations robust with reference to the harsh environment (ammonia, acid, dirt etc.)?

2. The pH meters are essential for correct function. It is therefore important to ensure that they are actually measuring correct. One could evaluate the calibration method and calibration interval and expected lifetime.

3. How can it be ensured that the level sensors (and possible flow meters) are working correct?

4. Safety around handling of the sulphuric acid – equipment and selection of material.

Field study results

The detailed robustness evaluation and recommendations were given directly to the representative from the equipment manufacturer present during the field study.

Overall reliability recommendations are given in annex 1 of the report.

It has been confirmed that the environmental conditions for this kind of equipment are very harsh. And that special care during design and construction must be made in order to ensure high robustness.

The actually observed harsh environmental conditions were:

Mechanical
- Vibration (when pump was running)
- Shock (pump start/stop, valve opening/closing)

Climatic:
- Dust (dirt inside cabinets)
- Possible traces of humidity inside pump control boxes

Chemical:
- Corrosion (both internally from leaking acid and from surrounding)

Other **expected** harsh environmental conditions (not investigated or observed during the 2 hour long inspection) are:

EMC (Electro Magnetic Compatibility)
- Emission of EMC noise from the system (radiated and conducted)
- Immunity to EMC noise from the surrounding (radiated and conducted)

Mechanical
- Impacts (during service or machinery moving in the vicinity of the system)

Climatic:
- Water (rain, snow, cleaning….)
- High temperatures (operation under intensive sun on a hot summer day)
- Low temperatures (cold start during cold winter days)
- Humidity (dew in a cold morning….)

Chemical:
- NH_4
- Slurry

Annex 1

Overall reliability recommendations

This is a list of overall reliability recommendations that can be given from the actual field study. The examples are specific from this field study, but the recommendations can be used generally. Note that only examples that may lead to low reliability is mentioned here – the many points with OK robustness are not mentioned. Some of the examples are not from the equipment delivered by Jørgen Hyldgaard Staldservice A/S, but from the “rest” of the slurry system.

Avoid sharp edges

Sharp edges around electrical cables may lead to failures due to ground/earth protection faults, short circuits or open-circuits. In order to avoid this, it is recommended that no electrical cables are situated close to sharp edges. The edges may be protected by use of rubber grommets or the cables may be fixed so that they will not get in contact with the sharp edges.

This is also relevant for pneumatic and hydraulic hoses.

Supply wires for pumps in slurry tank close to sharp edges in the concrete plate

Electrical wires in bottom of control cabinet in contact with sharp edge in the bottom plate

Heat trace cable in bottom of control cabinet in contact with sharp edge in the bottom plate

Dust inside cabinets

Dust was observed inside the slurry pump control cabinet which has been installed for many years. The dust may act as a carrier for electrical current and thus lead to failures due to ground/earth protection faults or short circuits. Dust can also hold corrosive elements in connection with humidity and dust may lead to fire hazard if deposited on hot parts. It is therefore recommended that the amount of dust coming into the cabinets is limited by use of some kind of filtering in the air ventilation areas (see also note concerning corrosion).

Dust inside slurry pump control cabinet

Use of armored/shielded cables

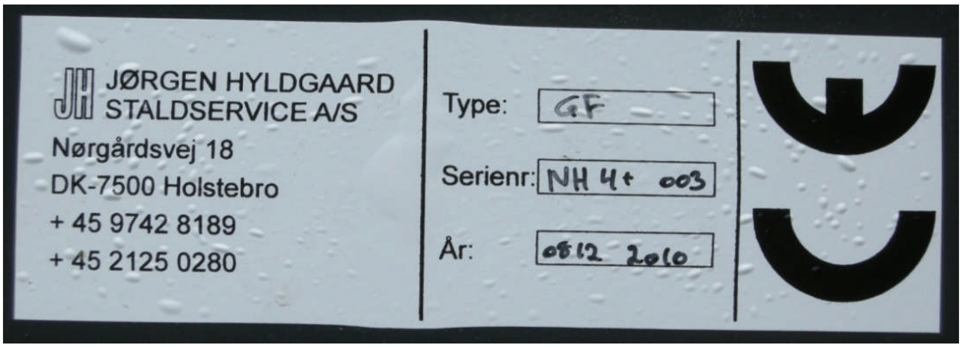
Many of the external cables on the system are of the armored type in order to obtain the necessary protection against animals and mechanical impacts as normal practice in the farm area. But there does not seem to be a clear EMC strategy for the system. EMC stands for ElectroMagnetic Compatibility, see Wikipedia definition below:

Electromagnetic compatibility (EMC) is the branch of electrical sciences which studies the unintentional generation, propagation and reception of electromagnetic energy with reference to the unwanted effects (Electromagnetic interference, or EMI) that such energy may induce. The goal of EMC is the correct operation, in the same electromagnetic environment, of different equipment which uses electromagnetic phenomena, and the avoidance of any interference effects.

A clear EMC strategy would mean that it has been considered which parts of the system that could be sensitive to EMI and how a suitable immunity level could be reached. One of the means to obtain suitable EMI robustness level is to use shielded cables so that possible EMI cannot enter the sensitive electronics via the input/output wires. And it could thus be a good idea to use the metal braided armor protection of the cables as EMI protection shield as well. This requires the ends of the shielded cable to be properly connected to the relevant ground planes in the electronic. Note that a standard earth protection lead (the yellow/green wire) cannot be considered as a proper EMI protection ground, as a piece of wire will not give protection against high frequency disturbances.

EMC requirements are more or less completely covered by the EMC requirements called out by the EMC directive published by EU (Directive 2004/108/EC). Compliance with the EMC directive requirements is shown by use of the CE-mark on the products.

The CE mark for the actual system was shown on the ID label for the system, see photo below.



System ID label with CE mark

And this mark implies that the manufacturer should hold a so-called “Technical File” where the delivered system is described in his internal product documentation.

The photos below shows were the shield in armored cables is not connected to any relevant ground plane (but only mechanically fixed in the plastic cable gland).

Cable entry into cabinet for electronics

Corrosion

Corrosion attacks were observed at several locations inside the control cabinet. Some corrosion was caused by direct spillage of acid, see photos below:

Corrosion attack below pump unit

Corrosion attack on and below valve

The corrosion caused by direct acid spillage may be reduced by ensuring a higher degree of tightness in and around the acid supply line and components. This is thus both relevant for proper selection of materials and components and for correct level of craftsmanship during assembling and service.

But other corrosion attacks were observed on locations without signs of direct acid spillage, see photos below:

Corrosion on edge of mounting bracket

Corrosion near top of control cabinet

The corrosion observed without indication of direct acid spillage, indicates that the outdoor farm environments contains gasses that can initiate atmospheric corrosion as expected.

The control cabinet was quite “open” in the sense that air could move quite free between the external ambient and the internal of the control cabinet. It may be alluring to try to make the control cabinet “tight”. But this is in practice very difficult, especially with many cables going in and out from the cabinet. And an almost tight cabinet with large masses inside may actually have a higher risk of getting into humidity/corrosion problems due to the so-called “Breathing effect” where water could be trapped inside enclosures when the ambient conditions are varying. It is therefore generally recommended to make outdoor cabinet after a “vented” principle. The 2 slurry pump control cabinets are made with this principle, see photos below. But as clearly seen, there is a large risk of clogged opening in dusty environments! And also a risk of getting dust inside the enclosures. A kind of membranes - like GoreTex - may prevent ingress of dust and direct water, but still allowing ventilation of the enclosure. Some kind of maintenance could, however, be expected in dusty environments.

Ventilation opening on the side of the new slurry pump control box

Ventilation opening on the side of the old slurry pump control box

Drift in sensors

A certain amount of drift must be expected for sensors situated in harsh environments. This is the case for the pH-sensors situated directly in the slurry. And as the accuracy of the pH measurement is crucible for the system performance, calibration and adjustment of the sensors must be done on a regular basis. The system manufacturer has already proposed and implemented regular check of the pH-sensors, but as this check includes adjusting in connection with the calibration and only observation of the values obtained after adjusting of the sensors, it is not possible to follow the drift in the sensors. If the drift of the sensor could be logged over time, it is possible to get information about when it can be expected that the sensor will be out of the required accuracy (i.e. when the “end-of-life” time is reached). A proposal for the regular check procedure could be:

- Calibrate the pH-sensor “as-it-is” (i.e. without adjustment) and log the value.
- Adjust the pH-sensor so the indicated value will be close to the reference value.
- Calibrate the pH-sensor after the adjustment and log the value.

The logged values should be stored in the system log file and the results should be analysed after each regular check in order to evaluate whenever the allowable drift limit is reached.

Heat trace cables

Heat trace cables are situated along the acid supply line in order to prevent freezing during cold weather. Control of the heat trace cable is made by use of a thermostatic device situated outdoor on a wall pointing to the north. And large parts of the heat trace cable are situated inside the thermal insulation sleeves surrounding the external part of the acid supply line. This is good. But some parts of the heat trace cables situated inside the control cabinet are not in good thermal contact with the parts to be heated, see photos below (the heat trace cable is the blue electrical wire approx. 6 - 8 mm thick). This may lead to freezing problems or, at least ,it will be waste of energy.

Blue heat trace cable inside thermal insulation: Good

Blue heat trace cable not in good contact with tubing and flanges

Blue heat trace cable not in good contact with pump housing