



Nature Energy Kvaers Measurement of air emissions Periodic measurements

**Accredited report 124-29980 A
Measurements performed in August 2024
Project manager: [REDACTED]**

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2024-09-04

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Resumé

FORCE Technology has performed measurements at Nature Energy Kvaers.

The main results are shown in Table 1.

Table 1 Result overview

Parameter	Unit	Biofilter 1	Biofilter 2
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Operating parameters

Temperature	°C	24	24
Flowrate	m ³ (s,d)/h	38.000	40.000

Concentrations

NH ₃	mg/m ³ (s,d)	0,16	< 0,10
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(s,d) indicates dry gas at standard conditions (0°C, 101,3 kPa)

< means below the limit of detection

The European decimal symbol (,) and digit grouping symbol (.) is applied.

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1 Introduction

FORCE Technology has in August 2024 performed measurements of air emissions at Nature Energy Kvaers:

Address: Felstedvej 35C, 6300 Gråsten

Company: Nature Energy

att. [REDACTED]

The measurements were performed by: [REDACTED]

The report was prepared by: [REDACTED]

Sampling and analysis is performed according to FORCE Technology's accreditation no. 51 and no. 8 from The Danish Accreditation and Metrology Fund (DANAK).

Results of the test are valid only for the specific plant, and plant operation during the test.

1.1 Scope of work

The scope of the measurements was to document the NH_3 emission from the two biofilters at Nature Energy Kvaers.

2 Results

When reporting in the English language the European decimal symbol (,) and digit grouping system (.) is applied for numbers and results.

2.1 Presentation of results

Table 2 Presentation of results – abbreviations and explanations

Abbreviations / example	Explanation
Rounding of values < 2	Results (except from O_2 , CO_2 and H_2O) are shown with a certain number of significant figures. Normally flow and concentrations are shown with two significant figures. O_2 , CO_2 and H_2O are shown with one decimal. Values below the limit of quantification are shown with one significant figure less than if detected and are shown with "<".
Mean values including values below the limit of quantification	Values below the limit of quantification are included in the mean value with the value of the limit of quantification. If one or more values are detected, the mean value is shown as detected, that is without "<".
Uncertainty	Uncertainty is not reported when results are below the limit of quantification.
Blank values	Correction for blank values is not required in the standard reference methods. If correction for blank is applied, it will be marked in the result table. If a sample value is below the blank value, it will be marked as not detected ("<").

2.2 Result overview

Table 3 Result overview

Plant/stack: After biofilter 1

Parameter	Unit	Sample 1	Sample 2	Sample 3	Average	Uncertainty (k=2)
Date	dd-mm-yy	06-08-2024	06-08-2024	06-08-2024	-	-
Measuring period	hh:mm	09:33 - 11:03	11:08 - 12:38	12:40 - 14:10	-	-
Measuring period, flow	hh:mm	08:15 - 08:23	08:24 - 08:31	14:11 - 14:16	-	-
Cross section area	m ²	0,7390			-	-

Operating parameters

Temperature	°C	23	24	24	24	± 1,5
Flowrate	m ³ (s,d)/h	39.000	37.000	37.000	38.000	± 2.000
Flowrate, operating conditions	m ³ /h	44.000	42.000	42.000	42.000	± 2.000

Concentrations

NH ₃	mg/m ³ (s,d)	< 0,08	< 0,09	0,31	0,16	± 0,06
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Mass emissions

NH ₃	kg/h	< 0,003	< 0,003	0,012	0,0060	-
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(s,d) indicates dry gas at standard conditions (0°C, 101,3 kPa)

< means below the limit of detection

The European decimal symbol (,) and digit grouping symbol (.) is applied.

Plant/stack: After biofilter 2

Parameter	Unit	Sample 1	Sample 2	Sample 3	Average	Uncertainty (k=2)
Date	dd-mm-yy	06-08-2024	06-08-2024	06-08-2024	-	-
Measuring period	hh:mm	09:45 - 11:15	11:23 - 12:53	12:56 - 14:26	-	-
Measuring period, flow	hh:mm	09:06 - 09:13	11:16 - 11:22	14:34 - 14:40	-	-
Cross section area	m ²	0,7390			-	-

Operating parameters

Temperature	°C	25	24	23	24	± 1,5
Water vapour (estimated)	%(f)	3,1	3,0	2,8	3,0	-
Flowrate	m ³ (s,d)/h	38.000	40.000	40.000	40.000	± 2.000
Flowrate, operating conditions	m ³ /h	43.000	45.000	45.000	44.000	± 3.000

Concentrations

NH ₃	mg/m ³ (s,d)	< 0,08	< 0,09	< 0,1	< 0,10	-
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Mass emissions

NH ₃	kg/h	< 0,003	< 0,003	< 0,005	< 0,004	-
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(s,d) indicates dry gas at standard conditions (0°C, 101,3 kPa)

< means below the limit of detection

The European decimal symbol (,) and digit grouping symbol (.) is applied.

2.3 Comments regarding the results

The detection limit varied between 0,08 and 0,1 mg/m³ and 5 of the 6 samples were below the detection limit.

3 Description of the plant

Process air from biogas production is split in two and cleaned in two parallel biofilters followed by emission to the atmosphere.

3.1 Plant operation

Information from the plant operator:
Normal production.

4 Measurements

4.1 Measuring methods

Applied measuring methods and uncertainties are specified in Appendix A.

4.2 Quality assurance

4.2.1 Field blanks

Field blanks are treated in the same way as an ordinary sample, though without passing an airflow through the sample. The blank value is calculated using the mean airflow through the samples in the series. At least one field blank is sampled pr. series of samples. For larger series of samples and for sampling over several days, extra field blanks are sampled. The results from field blanks are reported in the result overview. Results are not corrected for the blank value.

4.2.2 Sampling site and conditions during sampling

The layout of the sample site, and the existence of inaccessible traverse points, will influence the sample uncertainty. When the sample programme includes measurements of flow or velocity, a sampling site test is performed¹.

4.2.2.1 Sampling site

The sampling site is composed of two sampling ports located close to the fan that drives the flow from the biofilter to the stack. The flow measurements indicates that there is not a laminar flow at the measurement point. However, no other possible location could be used for measuring the flow. The flow is therefore measured in 4 places in the cross section at each measurement point, to get the best possible flow measurement in a tube with non-laminar flow.

The cross-sectional area of the duct is used in the calculation of measured flow. The area was measured.

Test for grid sampling (flow, velocity and particle bound parameters):

The sampling site has been tested according to EN 15259 and not suitable for grid sampling, thus the flow measurements are more uncertain than under normal conditions with laminar flow.

¹ Uncertainties at optimum sampling site conditions are given in Appendix A. A sampling site tested "not suitable", can lead to a significant rise in uncertainties for measurement of particle bound parameters and flow. Sampling site test are not performed, when the diameter of the duct is less than 300 mm.

Appendix A Measuring methods and uncertainties

Manual methods:

The limit of detection is given as what is usually achievable in a normal performance check, i.e, with 60 minutes sampling time, normal suction level, and accredited analysis. In some cases, the limit of detection can be either lower or higher than the stated value, for example a lower detection limit is achievable by increasing the sample volume. Methods that cover several parameters (e.g. trace metals), can have different limits of detection for different species, and in this case the lowest value is given. The limit of detection is defined as the average of repeated blank values plus three times the standard deviation of the same blank values.

The uncertainty is based on measurements performed at a sampling site that fulfils the demands in EN 15259 for grid measurements. When the demands in EN 15259 are not fulfilled, the uncertainty may become significantly larger. The uncertainty in the report is given in % of the measured value or as an absolute value. The uncertainty stated in this chapter is the usually achievable uncertainty at normal measured values well above the limit of detection.

Gas temperature:

The gas temperature is measured with either a pt100-thermocouple or a NiCr/NiAl-thermocouple connected to a digital thermometer or data logger. For temperatures over 200°C an extraction pyrometer is used, where the value is read at short intervals, or recorded with a datalogger.

Range: -40 - 600°C

< 100°C: Uncertainty (95% confidence interval, k=2): 1,5°C (absolute)

100-333°C: Uncertainty (95% confidence interval, k=2): 2,5°C (absolute)

> 333°C: Uncertainty (95% confidence interval, k=2): 0,75

Reference/standard: VDI 3511 bl. 1-5, IEC 584-2, IEC 584-2 amd. 1

Flow:

The gas velocity is measured by means of a pitot tube connected to an inclined tube manometer or a micro manometer, reading the dynamic pressure. The velocity is measured in a number of points in the cross section of the duct. From the velocity and the cross section area, the flow is calculated. A test of the sampling site suitability for grid measurements is always performed. The test is performed according to EN 15259, which in chapter 6.2 sets up requirements that shall be fulfilled in order to define the sampling site as suitable for grid measurements (flow, and isokinetic sampling).

EN 16911-1 stipulates correction for wall effects. In circular ducts, the correction factor is 0.995 if the inner surface is smooth and 0.99 if the inner surface is rough. In rectangular ducts, the correction factor should be calculated from USEPA Conditional Test Method CTM-041. The present measurements have been corrected with the factor 0,995.

Range: 0 - 40 m/s

Limit of detection: 1,7 m/s

Uncertainty (95% confidence interval, k=2): 6% of measured value.

Reference/standard: ISO/EN 16911-1, MEL-25

NH₃ concentration:

A partial flow of gas is aspirated through a filter followed in series by two impingers made of borosilicate glass with frit, each containing approx. 100 ml liquid solution (0.05 M H₂SO₄) in which the gaseous compounds are absorbed. A preheated and temperature controlled probe and filter is used. All parts of the sampling system in contact with the flue gas are made entirely of glass or other inert material. The gas flow is aspirated by means of a pump unit consisting of a gas tight pump, a calibrated gas meter, a flow meter for regulation of the flow, and a digital thermometer to monitor temperature after the pump and before the gas meter. The dry gas volume is determined by reading from the calibrated gas meter before and after each sample. The liquid solution is analysed by spectrophotometry. The impinger absorption efficiency has been tested to be better than the criteria of 95%.

Normal limit of detection: 0,2 mg/m³(s,d). In the current setup, the limit of detection varied between 0,08 and 0,1 mg/m³(s,d).

Uncertainty: 12 % of measured value (95% confidence interval).

Reference/standard: ISO EN 21877: 2019, MEL-24, analysis: modified with NH₃ analysis according to DS 224: 1975