

Report No.  
TNU 8000661189 / Line 2

23/05/2017  
TNUAM-E/Vo

## REPORT

### about Emissions Measurements

**Contracting body and Operator:** FORUS Energigjenvinning  
Forusbeen 202  
N 4313 Sandnes  
NORWAY

**Site:** Forusbeen 202,  
N 4313 Sandnes

**Plant:** Waste incineration plant / Line2

**Order No.:** 8000661189 / Line 2

**Order date:** 02 / 2017

**Measurement date:** March 16<sup>th</sup> – March 18<sup>th</sup> 2017

**Technical expert:** Mr. Vortherms  
☎ +49 160 888 4525  
✉ wvortherms@tuev-nord.de

**Report size:** 45 pages main report (Englisch)  
30 pages appendixes (German)

Accredited according to DIN EN ISO/IEC 17025:2005 by DAkkS - Deutsche  
Akkreditierungsstelle GmbH - accredited as an independent measuring laboratory  
The accreditation is valid for the testing procedures listed in the certificate.



Registered office  
**TÜV NORD Umweltschutz GmbH & Co. KG**  
Große Bahnstraße 31  
22525 Hamburg  
Tel.: +49 40 8557-2491  
Fax: +49 40 8557-2116  
umwelt@tuev-nord.de  
www.tuev-nord.de

Amtsgericht Hamburg  
HRA 96733  
USt.-IdNr.: DE 813376373  
Steuer-Nr.: 27/628/00058

Partner with unlimited liability  
TÜV NORD Umweltschutz Verwaltungs-  
gesellschaft mbH, Hamburg  
Amtsgericht Hamburg  
HRB 82195  
Geschäftsführer (CEO)  
Jana Petersik

Commerzbank AG, Hamburg  
BLZ: 200 400 00  
Konto-Nr.: 4090403  
BIC (SWIFT-Code): COBADEFF  
IBAN-Code: DE 83 20040000 0409040300

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 b BImSchG

## Report about Emission Measurements

Name of the accredited Institute	TÜV NORD Umweltschutz GmbH & Co. KG
Limitation of notification acc. to § 29 BImSchG	until 04 June 2019
Report No. (ref.) / report date	8000661189 / Line 2 / 23/05/2017
Operator	FORUS Energigjenvinning
Site	Site in Sandnes (N)
Type of measurement	Emission measurement to confirm the agreement with given statutory regulations
Order No. / order date	8000661189 / Line 2 / 02 / 2017
Date of measurement	March 16th – March 18th 2017
Report size	45 pages main report, 30 pages appendixes
Scope	Emission components given in statutory regulations of the plant to prove its compliance of operation (1 <sup>st</sup> Measurement campaign for the year 2017)

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## Summary

Plant		Waste incineration plant / Line2				
Operating times		24 h/d, all year				
Emission source		Incinerator stack				
Source number		n. a.				
Results						
Emission component	N	unit	Maximum value E <sub>B</sub>	Mean value E <sub>B</sub>	Emission limit value 24-hourly mean / ½ hourly mean	Operating condition > 80 % of design load
Total dust, incl. micro dust	4	mg/m <sup>3</sup>	<1	<1	10 / 30	yes
Mercury (Hg)	4	mg/m <sup>3</sup>	<0,01	<0,01	0,03	yes
Sum of Cd, Tl	4	mg/m <sup>3</sup>	<0,01	<0,01	0,05	yes
Sum of Sb, As, ..., V, Sn	4	mg/m <sup>3</sup>	<0,1	<0,1	0,5	yes
Sum of As, BaP, Cd, Co, Cr	4	mg/m <sup>3</sup>	<0,01	<0,01	0,05	yes
Carbon monoxide (CO)	15	mg/m <sup>3</sup>	6	1	50 / 100	yes
Hydrogen fluoride (HF)	4	mg/m <sup>3</sup>	<1	<1	1 / 4	yes
Hydrogen chloride (HCl)	4	mg/m <sup>3</sup>	1	1	10 / 60	yes
Total organic carbon (TOC)	5	mg/m <sup>3</sup>	<1	<1	10 / 20	yes
Nitrogen oxides (NO <sub>2</sub> )	15	mg/m <sup>3</sup>	212	167	200 / 400	yes
Ammonia (NH <sub>3</sub> )	4	mg/m <sup>3</sup>	1	<1	10	yes
Sulphur oxides (SO <sub>2</sub> )	4	mg/m <sup>3</sup>	39	33	50 / 200	yes
Dioxins/Furans (PCDD/F)	3	ng/m <sup>3</sup>	<0,1	<0,1	0,1	yes

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## 1 Objective / Discription of the measurement task

### 1.1 Contracting body / client

FORUS Energigjenvinning  
Forusbeen 202  
N 4313 Sandnes  
NORWAY

Contact person:

Mr. Rune Dirdal ☎ 0047 / 51 678400

Mr. Åge Byberg ☎ 0047 / 51 678400

### 1.2 Operator

FORUS Energigjenvinning  
Forusbeen 202  
N 4313 Sandnes  
NORWAY

### 1.3 Site

Location (local position):

Forusbeen 202

4313 SANDNES

On-site place:

-

### 1.4 Type of plant

Waste incineration plant

Operation name:

Line 2

### 1.5 Date of measurements

Date	March 16th – March 18th 2017
Date of last measurements	October 2016
Date of next measurements	Approx. October 2017

### 1.6 Reason for the measurement

Official measurement: Periodic measurement according to statutory regulations of the plant. First measurement of the year 2017.

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## 1.7 Objective

Measurement of relevant emission components given in statutory regulations of the plant, referencend to standard conditions (273 K, 1013,25 hPa), dry flue gas and 11 % oxygen content.

Component	daily (24 h) mean value	½-hourly mean value
Total dust, including micro dust (PM)	10 mg/m <sup>3</sup>	30 mg/m <sup>3</sup>
Mercury and its components, expressed as mercury (Hg)	0,03 mg/m <sup>3</sup>	-
The Sum of Cadmium and its components, expressed as Cd and Thallium and its components, expressed as Tl	0,05 mg/m <sup>3</sup>	-
The Sum of Antimony and its components, expressed as Sb Arsenic and its components, expressed as As Chromium and its components, expressed as Cr Cobalt and its components, expressed as Co Copper and its components, expressed as Cu Lead and its components, expressed as Pb Manganese and its components, expressed as Mn Nickel and its components, expressed as Ni Vanadium and its components, expressed as V Tin and its components, expressed as Sn	0,5 mg/m <sup>3</sup>	-
The Sum of Arsen and its components, expressed as As Benzo(a)pyren Cadmium and its components, expressed as Cd Cobalt and its components, expressed as Co Chromium and its components, expressed as Cr	0,05 mg/m <sup>3</sup>	-
Carbon monoxide (CO)	50 mg/m <sup>3</sup>	100 mg/m <sup>3</sup>
Gaseous inorganic hydrogen fluoride and its components, expressed as hydrogen fluoride (HF)	1 mg/m <sup>3</sup>	4 mg/m <sup>3</sup>
Gaseous inorganic hydrogen chloride and its components, expressed as hydrogen chloride (HCl)	10 mg/m <sup>3</sup>	60 mg/m <sup>3</sup>
Gaseous- and vaporous organic substances, expressed as total organic carbon (TOC)	10 mg/m <sup>3</sup>	20 mg/m <sup>3</sup>
Nitrogen monoxide (NO) and nitrogen dioxide (NO <sub>2</sub> ), expressed as nitrogen dioxide (NO <sub>2</sub> )	200 mg/m <sup>3</sup>	400 mg/m <sup>3</sup>
Ammonia (NH <sub>3</sub> )	10 mg/m <sup>3</sup>	-
Sulphur dioxide and sulphur trioxide, expressed as sulphur dioxide (SO <sub>2</sub> )	50 mg/m <sup>3</sup>	200 mg/m <sup>3</sup>
Polychlorinated Dibenzo(p)dioxins and Dibenzofurans (PCDD/F)	0,1 ng/m <sup>3</sup>	-

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## 1.8 Measurement components

Component	Number (N) of Measurements	Sampling period (each)
Total dust, including micro dust (PM)	4	1½ h
Mercury and its components, expressed as mercury (Hg)	4	1½ h
Cadmium and its components, expressed as Cd and Thallium and its components, expressed as Tl	4	1½ h
Antimony and its components, expressed as Sb Arsenic and its components, expressed as As Chromium and its components, expressed as Cr Cobalt and its components, expressed as Co Copper and its components, expressed as Cu Lead and its components, expressed as Pb Manganese and its components, expressed as Mn Nickel and its components, expressed as Ni Vanadium and its components, expressed as V Tin and its components, expressed as Sn	4	1½ h
Arsenic and its components, expressed as As Cadmium and its components, expressed as Cd Cobalt and its components, expressed as Co Chromium and its components, expressed as Cr	4	1½ h
Carbon monoxide (CO)	15	½ h
Gaseous inorganic hydrogen fluoride and its components, expressed as hydrogen fluoride (HF)	4	1½ h
Gaseous inorganic hydrogen chloride and its components, expressed as hydrogen chloride (HCl)	4	1½ h
Gaseous- and vaporous organic substances, expressed as total organic carbon (TOC)	5	½ h
Nitrogen monoxide (NO) and nitrogen dioxide (NO <sub>2</sub> ), expressed as nitrogen dioxide (NO <sub>2</sub> )	15	½ h
Ammonia (NH <sub>3</sub> )	4	1½ h
Sulphur dioxide and sulphur trioxide, expressed as sulphur dioxide (SO <sub>2</sub> )	4	1½ h
Polychlorinated Dibenzo(p)dioxins and Dibenzofurans (PCDD/F), Benzo(a)pyren	3	6 h

Flue gas conditions:

- Flue gas velocity / Exhaust gas volume flow
- Flue gas temperature
- Water content (Flue gas humidity)

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- Oxygen content (O<sub>2</sub>) as reference value
- Carbon dioxide content (CO<sub>2</sub>)
- Static Pressure and atmospheric pressure

## 1.9 Site inspection carried out before measuring

It was not necessary to carry out a site inspection, since the measurement conditions were well known from previous self-conducted measurement campaigns. In connection with the measurement planing it was confirmed by the operator, that no changes of the plant and the sampling site have occurred since the last measurement campaign.

## 1.10 Statement with whom the measurement plan was coordinated

Measurement plan coordination carried out	yes
with the operator	yes
with the competent supervisory authority	no, but the measurement plan is based on the given statutory regulations for the plant

## 1.11 Statement of personal involved on-site

Mr. Vortherms, TÜV Nord Umweltschutz ☎ +49 160 888 4525  
Mr. Schulte, TÜV Nord Umweltschutz  
experts of the TÜV NORD Umweltschutz GmbH & Co. KG

## 1.12 Other institutes involved

The analyses of PCDF/PCDD-samples und BaP-samples were carried out by Wessling Laboratorien GmbH, Oststraße 6, D-48341 Altenberge. Wessling Laboratorien GmbH is accredited according to DIN EN 17025 under the certificate No. D-PL-14162-01-00 for environmental sample testings.

## 1.13 Technical Responsibility

Dipl.-Ing. Stefan Wolynski	Temporary	Dipl.-Ing. Torsten Kalbach
☎ +49 511 9986 1283	position:	☎ 0201 825-2177
✉ swolynski@tuev-nord.de		✉ tkalbach@tuev-nord.de



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## 2 Description of the plant and matter handled

### 2.1 Type of plant

Waste incinerator

### 2.2 Description of the plants furnace and heat recovery system

Incinerator/boiler	
Manufacturer	Babcock Wilcox Vølund
Year of construction	2012
Design of incinerator	Moving grate incinerator
Fuel	municipal/ industrial waste
Calorific value	8 - 15 MJ/kg
Thermal input (max.)	24.4 MW
Capacity, waste	65.000 t/a
Gas fired burners	15.4 MW
Design of boiler	Evaporator, super heater and economizer
Steam produced:	28,8 t/h
Steam pressure:	40 bar g
Steam temperature:	400°C
Power produced /turbine	4.3 MWeI

### 2.3 Description of the emission sources

Emission source	Flue gas stack
Height above ground	47 m
Discharge area	Ø 1250 mm
Longitude (E)	5° 41' 56,9"
Latitude (N)	58° 53' 0,0"
Construction	Steel pipe, insulated

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## 2.4 Applied fuel according to statutory regulations of the plant

Waste key EAK	Indication EAK-decree	EAK-group
02 01 03 02 01 07	Waste from plant fabric Solid waste from forestry	Reject from production of raw materials
03 01 01 03 01 02 03 01 03	Bark - and Cork waste Sawdust Shavings, clippings, and waste material from wood and chip-board and veneer	Wood processing and from production of board and furniture
03 01 99	Other waste	
03 03 01 03 03 07 03 03 99	Bark Waste from recycling of paper and cardboard Other waste	Production and processing of cellulose, paper and cardboard
04 02 01 04 02 02 04 02 08	Waste from non treated fabrics and other natural fibre, predominant vegetable origin Waste from non treated fabrics and other natural fibre, predominant animal origin Waste from processed mixed textile fabric	Waste from textile industry
12 01 05	Parts of synthetic material	Waste from mechanical design (forging, welding, pressing, pulling, lathing, drilling, cutting and filing)
15 01 01 15 01 02 15 01 03 15 01 05 15 01 06	Paper and cardboard Synthetic material Wood Composite and laminated packaging Mixed materials	Packaging
15 02 01	Soak-up and filter material, cloth and protecting clothing	Soak-up and filter material, cloth and protecting clothing Sorted municipal waste (without glass, metal, paper)

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## 2.5 Operating times

The plant is operated continuously.

### 2.5.1 Total operating time

24 h/d all year

### 2.5.2 Emission time according to operators information

24 h/d all year

## 2.6 Description of the flue gas capture and treatment device

### 2.6.1 Installation for collection of flue gas

Waste incinerator with closed flue gas system

### 2.6.2 Installation for emission reduction

Manufacturer:

Simatek

Type:

JM 280 / 110-05.3c Code 2

Reactor and bag filter with lime and carbon injection

Flue gas flow:

MCR 49.000 Nm<sup>3</sup>/h

Flue gas temperature:

120 °C

Chimney Height:

47 m (above ground)

Dimension:

Ø 1250 mm

Construction:

Steel pipe, isolated

### 2.6.3 Installation for flue gas cooling

not applicable

## 3 Description of the sampling site

### 3.1 Position of the measurement cross section

Measuring devices for CO, HCl, Hg<sup>0</sup>, SO<sub>2</sub>, NO<sub>x</sub>, TOC and humidity

Position:	flue gas duct between fan and stack
Flow path	vertical
Undisturbed inlet section	4,0 m (< 5 D <sub>h</sub> )
Undisturbed outlet section	1,0 m (< 2 D <sub>h</sub> )
Distance to stack outlet	30 m (> 5 D <sub>h</sub> )
Angle between flue gas flow and flue gas duct centre axis < 15°	true
Local negative gas flow	not detected
Relation of highest to lowest local gas velocity within the measurement cross section < 3:1?	true
Meets the requirements of DIN EN 15259?	no <sup>(1)</sup>

Measuring devices for pressure, temperature and oxygen

Position:	flue gas duct between fan and stack
Flow path	vertical
Undisturbed inlet section	4,0 m (< 5 D <sub>h</sub> )
Undisturbed outlet section	1,0 m (< 2 D <sub>h</sub> )
Distance to stack outlet	30 m (> 5 D <sub>h</sub> )
Angle between flue gas flow and flue gas duct centre axis < 15°	true
local negative gas flow	not detected
relation of highest to lowest local gas velocity in the measurement cross section < 3:1?	true
Meets the requirements of DIN EN 15259?	no <sup>(1)</sup>

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## Measuring device for total dust, including micro dust

Position:	flue gas duct between fan and stack
Flow path	vertical
Undisturbed inlet section	4,0 m (< 5 D <sub>h</sub> )
Undisturbed outlet section	1,0 m (< 2 D <sub>h</sub> )
Distance to stack outlet	30 m (> 5 D <sub>h</sub> )
Angle between flue gas flow and flue gas duct centre axis < 15°	true
local negative gas flow	not detected
relation of highest to lowest local gas velocity in the measurement cross section < 3:1?	true
Meets the requirements of DIN EN 15259?	no <sup>(1)</sup>

## Measuring device for flue gas volume flow

Position:	flue gas duct between fan and stack
Flow path	vertical
Undisturbed inlet section	4,0 m (< 5 D <sub>h</sub> )
Undisturbed outlet section	1,0 m (< 2 D <sub>h</sub> )
Distance to stack outlet	30 m (> 5 D <sub>h</sub> )
Angle between flue gas flow and flue gas duct centre axis < 15°	true
local negative gas flow	not detected
relation of highest to lowest local gas velocity in the measurement cross section < 3:1?	true
Meets the requirements of DIN EN 15259?	no <sup>(1)</sup>

<sup>(1)</sup> According to the gas flow pattern and the process steps upstream, which do not yield to additional inhomogeneity a representative sampling is provided.  
The inlet and outlet sections are sufficient with respect to the necessary length of undisturbed inlet and outlet sections given by the manufactures of the measuring devices.

## 3.2 Size of the measurmet cross section

Diameter	1,40 m
Flow cross-section	1,539 m <sup>2</sup>
hydraulic diameter D <sub>h</sub>	1,40 m

### 3.3 Number of measuring axes and position of the measuring points in the measurement cross-section

Number of measurement axes	2
Number of measuring points	4

### 3.4 Number of measuring holes and size of gauge connection

Number of measuring holes	2
size of gauge connection	2½"

## 4 Measurement procedure and analytical method, instrumentation

### 4.1 Determination of the flue gas conditions

#### 4.1.1 Flue gas velocity

The dynamic pressures and flue gas velocities were determined once each with grid measurements before start of sampling, and used to calculate the volumetric flue gas flow rates. During the dust measurements the flue gas velocity was randomly checked at several reference points.

Measurement method	Dynamic pressure measurement
Probe	Prandtl's pitot tube
Indicating instrument	Electronic differential pressure gauge
Manufacturer   type	Airflow PVM 620
Measuring range	0 -3500 Pa
QA-No.   recent verification	82910725   02.2017

#### 4.1.2 Static pressure in the flue gas duct

Pressure gauge according to 4.1.1 applying the appropriate connectors

#### 4.1.3 Barometric pressure at the measuring site level

Type of measurement instrument	Precision-metal pressure gauge (barometer, compensated)
Manufacturer   type	Gotho, Bochum   DMU 4
QA-No.   recent verification	82910207   02.2017

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## 4.1.4 Flue gas temperature

The exhaust gas temperature was continuously measured using a temperature sensor. The temperature signals were recorded by a data logger and integrated according to the measurement time.

Thermocouple connected with a ALMEMO-Logger - continuous

Temperature sensor	Fe-Co-thermocouple
Data logger	Ahlborn Messtechnik ALMEMO® 2890-9
Temperature measurement method	thermal voltage measurement
Sampling rate   mean interval	10 Hz   20 s
QA-No.   recent verification	82910185   02.2017

## 4.1.5 Water vapour content, flue gas (Humidity)

Adsorption on Silicagel and gravimetric analysis according to DIN EN 14790

Flue gas sampling probe	Stainless steel tube with inlined quartz wool filter, controlled heated to approx. 180 °C
sampling device	1 condensate flask followed by 2 silica gel adsorption tubes
Sampling pump	Kutschera
QA-No.   recent verification	81980098   02.2016
scales, manufacturer   type	Kern   573-34NM
weighing range	0 – 650 g
resolution   precision	0,01 g
QA-No.   recent verification	82910745   02.2017

## 4.1.6 Flue gas density

Calculated result, based on the flue gas' constitution, humidity, temperature, and the absolute pressure in the the flue gas duct

## 4.1.7 Flue gas dilution

The flue gas is not being diluted.

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## 4.2 Continuous measurement methods

### 4.2.1 Measured objects

- oxygen (O<sub>2</sub>)
- carbon dioxide (CO<sub>2</sub>)
- carbon monoxide
- nitrogen oxides
- total organic carbon

#### 4.2.1.1 Measurement methods

Measured object	Measurement method	Standard
oxygen (O <sub>2</sub> )	paramagnetic measurement of test gas	EN 14789
carbon dioxide (CO <sub>2</sub> )	non-dispersive infrared spectrometry (NDIR)	ISO 12039
carbon monoxide (CO)	non-dispersive infrared spectrometry (NDIR)	EN 15058
Nitrogen oxides (NO, NO <sub>2</sub> )	chemiluminescence	EN 14792
Total organic carbon (TOC)	flame ionisation detection	EN 12619

#### 4.2.1.2 Analysers

Measured object	Manufacturer	Type	QA-No.
O <sub>2</sub> , CO <sub>2</sub>	Emerson Process Management (Rosemount Analytical)	NGA 2000 MLT 4	81360055
CO	Emerson Process Management	NGA 2000 MLT 4	81360055
NO, NO <sub>2</sub>	Emerson Process Management	NGA 2000 MLT 4	81360055
TOC	Bernath Atomic (now SICK)	BA 3006	82910115

#### 4.2.1.3 Measurement ranges adjusted

Measured object	Measurement range	Unit of measure
O <sub>2</sub>	0 to 25	Vol.-%
CO <sub>2</sub>	0 to 20	Vol.-%
CO	0 - 625	mg/m <sup>3</sup>
NO + NO <sub>2</sub>	0 to 513,5 expressed as NO <sub>2</sub>	mg/m <sup>3</sup>
TOC	0 to 10 (propane scale) 0 to 16,2 (propane scale)	ppm mg C/m <sup>3</sup>



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## 4.2.1.4 Analyser type approval tested

NGA 2000 MLT 4	Type approval announced in BAnz. <sup>1)</sup> 30.10.2004, No. 207, p. 22513.
BA 3006	Type approval announced in GMBI. <sup>2)</sup> 1996 No. 8, p. 188; BAnz. AT 23.07.2013 No. B4, p. 13.

## 4.2.1.5 Test site installation

Measured objects: carbon monoxide, carbon dioxide, nitrogen oxides, oxygen

Sampling probe, manufacturer / type  heated  maximum coverage	portable sampling probes with heated sample tube, M & C Tech Group Germany GmbH, Ratingen / PSP 4000  to 180 °C  1,2 m adaptable in length
Sample tube, manufacturer / type  heated  material	M & C Tech Group Germany GmbH, Ratingen / SP34-H/Ti  to 180 °C  stainless steel, teflon
Dust filter  material	outlying filter  quartz wool filter, heated to approx. 180 °C
Sample lines upstream measuring gas condi- tioning / treatment	length: 6,0 m, heated to 180 °C
measuring gas conditioning / treatment	yes
measuring gas cooler, manufacturer / type temperature controlled QA-No.	M & C / Cooler EC 2 °C 82910519 I 02.2017
Sample lines downstream measuring gas conditioning / treatment	length: 30 m, unheated
construction materials for transport of gas samples	stainless steel, teflon
desiccant	not used

<sup>1)</sup> Bundesanzeiger (Federal Gazette), Bundesministerium der Justiz, Mohrenstraße 37, D-10117 Berlin

<sup>2)</sup> GMBI Gemeinsames Ministerialblatt (Joint Ministerial Gazette), published by the Internal Affairs Minister of the Federal Republic of Germany

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Measured object: total organic carbon

Sampling probe, manufacturer / type	portable sampling probes with heated sample tube, M & C Tech Group Germany GmbH, Ratingen / PSP 4000
heated	to 180 °C
maximum coverage	1,2 m adaptable in length
Sample tube, manufacturer / type	M & C Tech Group Germany GmbH, Ratingen / SP34-H/Ti
heated	to 180 °C
material	stainless steel, teflon
Dust filter	inlying filter
material	ceramic filter, heated to approx. 180 °C
Sample lines upstream measuring gas conditioning / treatment	length: 6,0 m, heated to 180 °C
measuring gas conditioning / treatment	no
measuring gas cooler, manufacturer / type	n .a.
temperature controlled	
QA-No.	
Sample lines downstream measuring gas conditioning / treatment	n .a.
construction materials for transport of gas samples	stainless steel, Teflon, ceramic
desiccant	not used

## 4.2.1.6 Checking of the instrument curve with following test gases

Measured component	O <sub>2</sub>	CO <sub>2</sub>	CO	NO, NO <sub>2</sub>	TOC
Zero gas	nitrogen	nitrogen	nitrogen	nitrogen	nitrogen
Test gas	air	CO <sub>2</sub>	CO	NO	propane
Gas concentration	20,95	15,1	395,3	201 / 269	8 / 12,6
Unit	Vol.-%	Vol.-%	ppm	ppm / mg/m <sup>3</sup>	ppm / mgC/m <sup>3</sup>
Balance gas	-	nitrogen	nitrogen	nitrogen	nitrogen
Analysis tolerance	-	± 2 %	± 2 %	± 2 %	± 2 %
Manufacturer	-	Westfalen AG	Westfalen AG	Westfalen AG	Westfalen AG
Date of manufacturing	-	13.09.2016	13.09.2016	13.09.2016	12.02.2016

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Gas cylinder No.	-	2760050317 9194	2760050317 9194	2760050317 9194	276005027161 16
Stability warranty	-	24 month	24 month	24 month	24 month
Certificate No.	-	3968560	3968560	3968560	3964849
Test gas fed to the measurement system upstream the filter element	yes	yes	yes	yes	yes

#### 4.2.1.7 90 % response time (T90) of the complete measurement instrument system

For all measured components: < 39 sec.

The T90 time was determined by switching flue gas or test gas to the measurement systems sample probe.

#### 4.2.1.8 Capture and recording of measurements

The data signals of the analysers were acquired by a data logger as 20 sec. mean values and subsequently condensed to half hourly means.

Data logger	Ahlborn Messtechnik ALMEMO 2890-9
QA-No.	82910185   02.2017
Current input plug	Type ALMEMO ZA 9601-FS1 shunt E4
Input signal	- 32 bis +32 mA
Resolution	16 Bit (0,001 mA)
Sampling rate / mean interval	10 Hz / 20 sec.
Data processing	Ahlborn Messtechnik ALMEMO 2890-9
Software / program	AC 5.13.0.344
Accuracy	0,5
Recording / visualisation	with laptop
Integration time	20 sec.

#### 4.2.1.9 Quality assurance measures

The gas analysers and the equipment for sampling, sample conditioning and data acquisition are checked in the framework of the inspection equipment monitoring by TÜV NORD Umweltschutz GmbH & Co. KG. Additionally, the adjustment of the devices was checked on-site with entrained test gases, before and after finishing the measurements. It was assured by a sufficiently long warm-up phase that no unacceptable drifts of zero and reference points occurred during the measurement period. The gas circuit

was checked for leaks by comparing the devices readings when test gases are fed either directly to the analyser or to the probe tip. No unacceptable deviations were found.

## 4.3 Discontinuous measurement methods

### 4.3.1 Gaseous and vaporous emissions

#### 4.3.1.1 [HF] Gaseous inorganic fluorine compounds indicated as hydrogen fluoride

#### 4.3.1.2 [HF] Measurement method / VDI-guideline:

Absorption of fluorides from a partial flue gas stream in diluted sodium hydroxide solution according to VDI-guideline 2470 part 1 and AB 721102, respectively.

#### 4.3.1.3 [HF] Sampling instrumentation:

Sampling probe, filter, material: Quartz tube, heated with upstream particle filter (quartz wool, heated)

Absorption unit: downstream the particle separation unit 2

Absorbent / -amount: quartz glas frit washing bottles in series

Distance intake sampling probe to absorbent: dilute sodium hydroxide solution / 2 x 40 mL

Gas sample pump: 6,0 m

Duration of sample transfer: Kutschera

External laboratory involved: QA-No.: 81980098 I 02.2017

4 weeks

no

#### 4.3.1.4 [HF] Analysis:

After sampling was finished, the absorbent in both washing bottles was analysed in the laboratory on the basis of guideline VDI 2470, BI. 1, method B. The measurement of the fluoride concentration was carried out by ionsensitive single-rod measuring cell. After adjustment to pH 5,5 the electrode potential of the lanthanum fluoride crystal membrane in contact with the fluoride solution is measured to determine its concentration.

pH-/ion meter

Manufacturer: WTW

Type: inoLab / pH Ion 735

Measuring cell: Fluoride-single-rod F- 106667 WTW

Calibration is carried out using different dilutions of a volumetric sodium fluoride basis solution.

#### 4.3.1.5 [HF] Method performance data:

Selectivity:

To each sample different definite amounts of fluoride were added (standard addition procedure, DIN 32633). Matrix effects at low fluoride concentrations are therefore cleared.

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Referred to a sample volume of 100 ml the following performance data are achieved:

Detection limit:	0,01 mg/sample
Determination limit:	0,02 mg/ sample
Quantification limit:	0,03 mg/ sample

Analytical measurement uncertainty:  $U_c = 2,75 \%$

## 4.3.1.6 [HF] Quality assurance measures:

- Leak testing of the complete sampling device
- Use of certified measurement devices for temperature, gas volume and gas pressure. Generation and analysis of a blank sample for each sampling series

## 4.3.2.1 [HCl] Gaseous inorganic chlorine compounds indicated as hydrogen chloride

### 4.3.2.2 [HCl] Measurement method / VDI-guideline:

The gas sample is drawn through the probe and a filter to remove particles, and subsequently through 2 glass washing bottles in series to absorb gaseous and vaporous chlorides. The materials in contact with the gas between flue gas duct and absorption device are heated.

Analysis:	Ion chromatography
VDI-guideline / EU-standard:	DIN EN 1911
AB:	721101

### 4.3.2.3 [HCl] Sampling instrumentation:

Sampling probe, material:	stainless steel (heated)
Particle filter:	quartz wool, heated (150 °C)
Absorption unit:	2 quartz glass washing bottles in series
Absorbent / -amount:	distilled water / 2 x 40 mL
Distance intake sampling probe to absorbent:	6,0 m
Gas sample pump:	Kutschera QA-No.: 82910822 I 11.2016
Duration of sample transfer:	4 weeks
External laboratory involved:	no

### 4.3.2.4 [HCl] Analysis:

The absorbents of the two washing bottles were united and diluted with distilled water to a total volume of 100 mL. This solution is subjected to ion-chromatography either directly or after appropriate dilution.

Analyser	Ion chromatograph
Manufacturer:	Dionex
Type:	2010; conductivity detector
Eluent:	solution of 0,75 mmol/L sodium bicarbonate (NaHCO <sub>3</sub> )

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- Data acquisition/chem station: 1,50 mmol/L sodium carbonate ( $\text{Na}_2\text{CO}_3$ )  
PC / software Dionex AL 450
- 4.3.2.5 [HCl] Method performance data:  
Detection limit: 0,023 mg/L HCl  
Determination limit: 0,046 mg/L HCl  
Quantification limit: 0,093 mg/L HCl  
Analytical measurement uncertainty:  
 $U_{c1} = 5,50 \%$   
 $U_{c2} = 2,20 \%$
- 4.3.2.6 [HCl] Quality assurance measures:  
➤ Leak testing of the complete sampling device
- 4.3.2.1 [NH<sub>3</sub>] Ammonia and gaseous inorganic ammonia compounds indicated as ammonia
- 4.3.2.2 [NH<sub>3</sub>] Measurement method / VDI-guideline:  
The gas sample is drawn through the probe and a filter to remove particles, and subsequently through 2 glass washing bottles in series to absorb gaseous ammonia compounds. The materials in contact with the gas between flue gas duct and absorption device are heated.  
Analysis: Photometry, indophenol method  
VDI-guideline: VDI 3496 part 1
- 4.3.2.3 [NH<sub>3</sub>] Sampling instrumentation:  
Sampling probe, material: stainless steel (heated)  
Particle filter: quartz wool, heated (180 °C)  
Absorption unit: 2 glass frit washing bottles in series  
Absorbent / -amount: 0,05 mol/L sulfuric acid ( $\text{H}_2\text{SO}_4$ ) / 2 x 40 mL  
Distance intake sampling probe to absorbent: 6,0 m  
Gas sample pump: Kutschera  
QA-No.: 82910822 I 11.2016  
Duration of sample transfer: 3 weeks  
External laboratory involved: no
- 4.3.2.4 [NH<sub>3</sub>] Analysis:  
The absorbents of the two washing bottles are analysed in the laboratory according to VDI 3496, part 1. The ammonia concentration is determined by the indophenol procedure using the Macherey-Nagel rapid test Nanocolor 0-03 / 0-04. The analytical detection is carried out photometrically at 690 nm wavelength.  
Analyser: Photometer,  
Manufacturer: Macherey-Nagel  
Type: Nanocolor 300 D

For the analysis a device-internal calibration function is acquired, which is periodically checked against reference standards and a blank solution.

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4.3.2.5 [NH<sub>3</sub>] Method performance data:  
Determination limit: 0,05 mg/L  
Analytical measurement  
uncertainty: U<sub>c</sub> = 4,27 %

4.3.2.6 [NH<sub>3</sub>] Quality assurance measures:  
➤ Leak testing of the complete sampling device

Before sampling, the apparatus was checked for leaks by closing the probes' tip while the sampling pump is in running. The automatic gas sampler is subject to regular internal calibration of the TÜV NORD GmbH & Co. KG. This ensures that the measurement uncertainty of the sample volume metering equipment used does not exceed 2% of the indicated value and the measurement uncertainty of the measuring instruments for pressure and temperature does not exceed 2% of the reading.

Sampling and analysis are checked by a field blank. The precision of the analytical measurement is regularly checked with control samples and documented in control charts.

The laboratory of TÜV NORD Umweltschutz GmbH & Co. KG accounts control charts according to DIN EN ISO 17025 for the analytical part of this measuring process.

4.3.3.1 [SO<sub>2</sub>] Sulfur oxides

4.3.3.2 [SO<sub>2</sub>] Measurement method:  
Determination of the SO<sub>2</sub> content by H<sub>2</sub>O<sub>2</sub> oxidation of the sampled gas with subsequent ionenchromatographic analysis of the formed sulfate.

Standard: EN 14791

4.3.3.3 [SO<sub>2</sub>] Sampling instrumentation:

Sampling probe, material: stainless steel (heated)  
Particle filter: quartz wool, heated (180 °C)  
Absorption unit: 2 quartz glas frit washing bottles in series  
Absorbent / -amount: 3 % H<sub>2</sub>O<sub>2</sub> solution, 2 x 40 ml  
(For the expected concentration range the applicability of this solution was proven by validation measurements.)

Distance intake sampling probe  
to absorbent: 6,0 m  
Gas sample pump: Kutschera  
QA-No.: 82910005 I 02.2017  
Duration of sample transfer: 4 weeks  
External laboratory involved: no

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## 4.3.3.4 [SO<sub>2</sub>] Analysis

In the absorption solution sulfur dioxide is oxidised by H<sub>2</sub>O<sub>2</sub> to SO<sub>4</sub><sup>2-</sup>.  
The sulfate ions formed were quantified by ion chromatography.

Analyser ion chromatograph  
Manufacturer: Dionex company  
Type: ICS 1100

## 4.3.3.5 [SO<sub>2</sub>] Method performance data

Cross interference: organic acids may interfere the result  
Detection limit: 0,022 mg/l  
Determination limit: 0,044 mg/L  
Quantification limit: 0,087 mg/L  
Analyts recovery rate: no deviation from EN 14791

Analytical measurement

uncertainty: U<sub>c</sub> = 3,63 %  
U<sub>c</sub> = 2,37 %

## 4.3.3.6 [SO<sub>2</sub>] Quality assurance measures:

- Leak testing of the complete sampling device
- field blank test
- use of certified instruments for measuring pressure and temperature
- Regular participation in round robin tests

## 4.3.4 Particulate emissions

### 4.3.4.1 Measured object

Total dust, including micro dust

### 4.3.4.2 Measurement method

manual gravimetric method according to the principles of the VDI guideline 2066, part 1 and EN 13284-1

### 4.3.4.3 Test site installation

filter apparatus	4 m <sup>3</sup> /h plane filter device for plane filters, Ø: 45 mm
manufacturer	Paul Gothe GmbH, Bochum
arrangement of the separation device	filter device inside duct (IN-Stack), unheated
sample nozzle	titanium, unheated
effective diameter of the nozzle	see evaluation of dust measurements in the appendix of this report
separation device	filter device and plane filter mount made of titanium for plane filters Ø: 45 mm



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separator medium	quartz fiber filter Whatman (UK)
separation efficiency	99,9 % (manufacturer specifications)
sample gas drying	condensate trap
	drying tower incl. approx. 5 kg silica gel
checking of suction speed	zero pressure method floating body flow meter
sample volume metering	dry gas meter G4, arranged upstream of the pump on the depressed side
QA-No.   recent verification	82910124   02.2017
partial flow generation	oil lubricated rotary vane vacuum pump, 6 m³/h

The measurement set accords figure 3 of the EN 13284-1, and the filter and separation devices used comply with figure E1 of the EN 13284-1.

#### 4.3.4.4 Handling of the separator medium and the sedimentary deposition

transport and storage	plane filter in its mount, in petri dishes; rinsing solution in PE bottles
recocery of sedimentary deposition upstream of the filter	no weighable depositions, not applicable
Drying temperature and drying time of the separator medium	
- before loading	160 °C, 24 h
- after loading	160 °C, 24 h
weighing	
air conditioned weighing chamber	yes
scales	Sartorius, Göttingen / Typ M 3 P
weighing range	0 – 1.500 mg
display accuracy	0,001 mg

#### 4.3.4.5 Work up and evaluation of the measuring filters and the absorption solutions

The sample work up procedure and the analysis (weighing) are described in chapter 4.3.2.4. The analysis on dust ingredients was unnecessary.

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## 4.3.4.6 Method performance data

medium	plane filter	evaporating dish
detection limit	0,13 mg	not applicable
weighing uncertainty	0,05 mg	not applicable
field blank	see analysis report < 0,1 mg abs.	not applicable

## 4.3.4.7 Quality assurance measures

The sampling apparatus is cleaned up to the separator medium before each measurement series and visually checked for debris before each sampling.

The sampling apparatus is checked for leaks before each sampling.

A field blank is determined for each sampling series.

All equipment for the determination of the sample volume, and for the analysis of the samples are subject to the inspection equipment monitoring of TÜV NORD Umweltschutz GmbH & Co. KG and they are checked annually for function and alignment.

The scales used for the gravimetric analysis of the samples is annually traceable calibrated in accordance with Quality Assurance Handbook and is checked each day of use with two standard weights.

### 4.3.5.1 [Metals, semi-metals and its compounds]

Arsenic, antimony, lead, cadmium, chromium, cobalt, copper, manganese, nickel, thallium, vanadium, tin

### 4.3.5.2 [Metals...] Measurement method / VDI guideline

Determination of the total emission of As, Cd, Cr, Co, Cu, Mn, Ni, Pb, Sb, Tl and V

The measurements are made in accordance with EN 14385 by the "total flow" method. In the total-flow method, the sampling is carried out by isokinetic partial flow sampling according to the VDI guideline 2066 part 1 with a titanium apparatus consisting of suction nozzle with 90° bend, plane filter device with plain filter, heated suction tube and a washing bottle rack with three impingers.

The adhering particle-bound metals on the plane filter are digested wet chemically and quantified by atomspectrometry. The filterpassing fraction of metals solved in the absorption solutions is suitably treated also quantified by atomspectrometry.

Taking into account the volume of sampled gas, the concentrations of particle-bound and filterpassing metals are calculated and summarized as totals.

### 4.3.5.3 [Metals...] Test site installation

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Restraint system for particle bound matter  
plane filter device, in-stack made of titanium according to EN 14385  
separator medium: quartz fiber plane filter  
manufacturer / type: Whatman (UK) quartz fiber filter  
Filter diameter: Ø 45 mm  
separation efficiency : 99,9 % (manufacturer specifications)

Absorption system für filterpassing matter  
Absorption device: 3 impinger washing bottles in series  
Absorbent / amount: HNO<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> - solution, 3 x 60 ml  
Distance intake sampling probe  
to absorbent: approx. 2 m  
Gas pump: rotary-slide pump  
Gas meter: Elster G4  
QA-No.: 82910124 I 02.2017  
Duration of sample transfer: 2 weeks  
External laboratory involved: no

4.3.5.4 [Metals...] Handling of the separator medium and the sedimentary deposition:  
To quantify the elements, the plane filters were micro wavelly digested according to EN 14385 in a micro wave oven MARS by CEM and subsequently analysed. There were no deposits.

4.3.5.5 [Metals...] Work up and evaluation of the measuring filters and the absorption solutions:  
The filter-passing fraction of metals dissolved in the absorption solutions is analysed after transport to the laboratory directly by ICP-OES and G-AAS according to EN 14385.

## Analyser ICP-OES

Manufacturer: Perkin-Elmer  
Type: Optima 3000  
resolution: approx. 7 pm  
Power: 1300 W at 0,8 ml spray gas

## Analyser graphit tube-AAS (G-AAS)

Manufacturer: Perkin-Elmer  
Type: SIMAA 6000  
Graphit tube furnace: HGA 700  
Autosampler: AS 72

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## 4.3.5.6 [Metals...] Method performance data:

For 200 ml of absorption solution, the following performance data are achieved:

Element	Detection limit [µg/l]	Determination limit [µg/l]	Quantification limit [µg/l]	Method	Analytical measurement uncertainty $u_c$ [%]
Cd	0,06	0,12	0,25	G-AAS	3,72
Tl	0,3	0,6	1,2	G-AAS	4,77
Sb	1,2	2,5	5,0	G-AAS	3,71
As	1,0	2,0	3,8	G-AAS	3,43
Pb	1,0	2,0	4,1	G-AAS	2,64
Cr	0,4	0,8	1,5	ICP-OES	1,97
Co	0,6	1,2	2,3	G-AAS	3,85
Cu	0,6	1,3	2,5	ICP-OES	3,70
Mn	0,1	0,3	0,6	ICP-OES	2,27
Ni	0,7	1,3	2,7	G-AAS	3,66
V	0,9	1,9	3,7	ICP-OES	1,86
Sn	1,1	2,1	4,2	G-AAS	3,92

The absorption lines used are consistent with the requirements of DIN 38406, part 22.

### Selectivity:

A unique identification of the signals is given by the analyser.

## 4.3.5.7 [Metals...] Quality assurance measures:

- Leak testing of the sampler
- Compliance with the isokinetic conditions throughout the entire sampling period
- Use of certified measuring instruments for temperature, pressure and gas volume.

### 4.3.5.1 [Hg] Mercury and its compounds:

#### 4.3.5.2 [Hg] Measurement method / VDI guideline

EN 13211, manual method for determination of the concentration of total mercury

The measurements are carried out in accordance with EN 13211. The sampling is carried out by isokinetic partial flow sampling according to the EN 13284 part 1 with a titanium apparatus consisting of suction nozzle with 90° bend, plane filter device with plain filter, heated suction quartz glass tube. The heated gas sample probe is proportionally divided into a flow to an absorption system and into a main bypass-flow. The absorption system consists of a washing bottle rack with at least two impingers in series.

Particle bound mercury is retained on the surface of the plane filter. The filtered sample gas flow, containing vaporous and gaseous mercury components is passed through the

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gas washing bottles, filled with sulfuric acidic potassium permanagnate absorbent. There the mercury is oxidatively trapped.

The adhering particle-bound mercury on the plane filter is digested wet chemically and quantified by cold vapour AAS. The filterpassing fraction of mercury in the absorbing medium is liberated from precipitated manganese dioxide with hydroxyl ammonium chloride and also quantified by cold vapour AAS directly after reduction with tin-II-chloride.

Taking into account the volume of sampled gas, the concentrations of particle-bound and filterpassing mercury are calculated and summarized as totals.

## 4.3.5.3 [Hg] Test site installation

Restraint system for particle bound matter

plane filter device, in-stack made of titanium according to EN 13211

separator medium: quartz fiber plane filter

manufacturer / type: Whatman (UK) quartz fiber filter

Filter diameter: Ø 45 mm

separation efficiency : 99,9 % (manufacturer specifications)

Absorption system für filterpassing matter

Absorption device: 2 impinger washing bottles in series

Absorbent / amount:  $\text{KMnO}_4/\text{H}_2\text{SO}_4$  - solution, 2 x 30 ml

Distance intake sampling probe to absorbent: 2 m

Gas pump: rotary-slide pump

Gas meter: Elster G4

QA-No.: 82910687 I 02.2017

Sampler: Kutschera, QA no: 82910005 I 02.2017

Duration of sample transfer: 2 weeks

External laboratory involved: no

## 4.3.5.4 [Hg] Handling of the separator medium and the sedimentary deposition:

To quantify the mercury, the plane filters were micro wavely digested according to EN 13211 in a micro wave oven MARS by CEM and subsequently analysed.

There were no deposits.

## 4.3.5.5 [Hg] Work up and evaluation of the measuring filters and the absorption solutions:

The filter-passing fraction of mercury fixed in the absorption solutions is analysed in the laboratory after being liberated from precipitated manganese dioxide with hydroxyl ammonium chloride. In a manifold the prae reduced solution is fully reduced with tin-II-chloride and immediatly analysed by cold vapour AAS according to EN 13211.

### Analyser cold vapour AAS

Manufacturer: Perkin-Elmer

Type: FIMS 2100 with FIAS 400

Calibration methodology

Standard calibration method with external matrix based standards.

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## 4.3.5.6 [Hg] Method performance data:

Cross interference:	no significant influences
Detection limit:	0,02µg/sample
Determination limit:	0,03µg/sample
Quantification limit:	0,06 µg/sample
Analyts recovery rate:	no deviation from EN 13211
Analytical measurement uncertainty:	U <sub>c</sub> = 5,26 %

## 4.3.5.7 [Hg] Quality assurance measures:

- Leak testing of the complete sampling device
- field blank test
- use of certified instruments for measuring pressure and temperature and gas volume

## 4.3.6 Particular highly toxic flue gas constituents (PCDD / PCDF, etc.)

### 4.3.6.1 measuring object: polychlorinated dibenzodioxins and dibenzofurans (PCDD/F) and benzo(a)pyrene (BaP)

4.3.6.2 Measurement method: EN 1948 part 1 to 3; cooled probe method, PCDD / PCDFs and BaP are sampled together.

### 4.3.6.3 Test site installation:

Test site installation:

Sampling probe:

Isokinetic partial flow extraction over water-cooled titanium-sampling probe with glass inlet (maufacturer: Paul Gothe - Foundation, Bochum))

Flow control:

zero-differential-pressure control,  
Paul Gothe Foundation  
QA No.: 82910780

Absorption device:

High performance spiral condenser, condensate flask and adsorber cartridge with XAD2 resin. The high performance spiral condenser is cooled by cryostat to approx. 5 °C.

Sorbent / type and amount: 2 x approx. 15 g solid adsorbent (XAD2 resin) with plane filter upstream the backup adsorbent layer

Gas pump:

Manufacturer:

Paul-Gothe Foundation, Bochum

design flow rate:

10 m<sup>3</sup>/h

Gas meter:

Elster G6 QA No.: 82910780 I 02.2017

Duration of sample transfer:

2 weeks

External laboratory involved:

yes, see chapter 1.12

## 4.3.6.4 Sampling and on-site sample work up procedure

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A leak test was carried out before the start of the flue gas sampling. Therefore, the probe tip was sealed while the sample pump was running.

After sampling, the parts of the sampling equipment, which have come into contact with the sample, were rinsed with acetone. These flushing liquids were added to the corresponding sample matrix before the extraction procedure was started.

The samples were shipped at ambient temperature in a metal box and stored in a refrigerator until the beginning of the analytical treatment on 28/03/2017. The GC injection of the worked up extract was carried out 05/04/2017.

## 4.3.6.5

### Analysis:

The sample work up and analysis was carried out by Wessling Laboratorien GmbH according to EN 1948-2.

#### a) PCDD/PCDF

Sample work up (laboratory):

Before beginning the sample work up, <sup>13</sup>C-labeled quantification standards are added to account for possible analyt losses during the column chromatography purification steps. For quality control of the entire sample work up procedure <sup>13</sup>C-labeled injection standards were added after the last purification step.

The condensate phase is extracted with toluene. The adsorption "XAD-2" (and PU foam) is hot-extracted together with the plane filter in a Soxhlet apparatus with toluene. After this, all organic extracts were combined, concentrated and cleaned from interfering components by a multistep column chromatographic purification. The analytes were separated by high resolution capillary gas chromatography and detected with a high resolution mass spectrometer.

Gas chromatograph:	Thermo, Type: GC-Ultra Autosampler: Tri-Plus Carrier gas: Helium
GC column:	PCDD/F, DB 5-MS, 60 m by J & W splitless injektion at 280 °C
Mass spectrometer:	Thermo, Type: DFS R > 10.000, SIM-Mode

The quantitative determination is carried out by isotope dilution method. For each group of homologes two isotope masses of the molecular ion cluster are monitored and quantified according to EN 1948-3.

#### b) BaP

Sample work up and analysis were carried out by Wessling Laboratorien GmbH according to ISO 11338-2 as follows:

An aliquot of the toluene extract isolated on the work up procedure of the PCDF/PCDD is chromatographically purified using a multilayer column. BaP is eluted

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from the column with acetonitrile. The quantitative determination is carried out by high-performance liquid chromatography (HPLC) with fluorescence detector according to the method of external standards.

## 4.3.6.6 Method performance data:

### a) PCDD/PCDF:

Individual performance data for each sampling series cannot be obtained. Instead of this, the analytical result of the field blank sample is merged to the stack of analytical field blank results collected in the past, and evaluated according to EN 20988 to calculate for the method performance data. The sampling method used is generally validated (EN 1948-1).

To check the efficiency of the sampling procedure, <sup>13</sup>C-labeled sampling standards are added into the condensate flask of the sampling apparatus before the start of sampling. The quality of the samples restraint can then be checked by comparison of the abundances of the sampling standards with the abundances of the work up standards. This so-called sample recovery rate is, according to EN 1948-2, not taken into account in calculating the analytical results, because the unlabelled PCDF / PCDD in the flue gas are mainly bound to particles and behave different with respect to the adsorption property of XAD-2 compared to the added <sup>13</sup>C-labeled standards which are dissolved in organic solvent.

The quality of the sample purification is generally monitored by <sup>13</sup>C-labeled control standards.

In a single measurement validation according to EN 1948-1, No. 6.1, applying an additional adsorption cartridge it was proved, that more than 99,9% of the detected PCDF/PCDD were trapped in the standard sampling equipment.

Extended uncertainty,  
analysis contribution:

15 % (referred to a single congener)

5 % (referred to the toxicity equivalent (TE) value)

### b) Benzo(a)pyrene:

Quantification limit: 1 µg/sample

Uncertainty, analysis contribution: U<sub>c</sub> = 2,7 %

## 4.3.6.7 Quality assurance measures:

- Leak testing of the complete sampling device
- field blank test
- use of certified instruments for measuring pressure and temperature and gas volume

## 4.3.7 Odour emissions

Not applicable



## 5 Plant operating conditions during the measurements

### 5.1 Operational data of the waste incinerator

The incinerators operation point during the days of measurement is listed below:

Parameter		1 <sup>st</sup> Day	2 <sup>nd</sup> Day	3 <sup>rd</sup> Day
Date	2017	16.03.	17.03.	18.03.
Time	from	Uhr	09:30	9:15
	to	Uhr	16:15	16:00
Thermal output	MW	14,51	14,43	14,33
Primary air volumetric flow rate	m <sup>3</sup> /h	14276	13333	13551
Secondary air volumetric flow rate	m <sup>3</sup> /h	7720	8616	6739

The data were acquired and recorded by employees of the TÜV NORD Umweltschutz GmbH & Co. KG using the plants master control station meters.

Deviations from normal operation were not observed.

### 5.2 Operational data of flue gas purification facilities

Parameter		1 <sup>st</sup> Day	2 <sup>nd</sup> Day	3 <sup>rd</sup> Day
Date	2017	16.03.	17.03.	18.03.
Temperature secondary chamber	°C	980	978	976
lime	%	-	-	-
carbon	%	-	-	-

The flue gas cleanig devices, fabric filter and flue gas recirculation, were driven in undisturbed specified normal operation.

The data were acquired and recorded by employees of the TÜV NORD Umweltschutz GmbH & Co. KG using the plants master control station meters.

Deviations from normal operation were not observed.

## 6 Summary of the results and discussion

### 6.1 Evaluation of the operation conditions during the measurements

The furnace, emission abatement and heat recovery system were operated within given statutory regulations.

The requirement of the German Technical Instructions on Air Quality Control (TA Luft) No. 5.3.2.2 for the plants operation condition leading to highest emissions was met. The measurements are representative for the incinerator plants emission behavior.

### 6.2 Results of measurements

The volume and concentration data given in the following chapter and in the appendix of this test report are referenced to standard conditions (273,15 K and 101,3 kPa) after subtraction of the water vapour content unless explicitly indicated otherwise.

According to No. 5.1.2 of the German Technical Instructions on Air Quality Control (TA Luft) emission mass concentrations are referred to reference oxygen content of 11 vol - %.

#### 6.2.1.1 Peripheral flue gas parameters

Parameter		1 <sup>st</sup> Day	2 <sup>nd</sup> Day	3 <sup>rd</sup> Day
Date	2017	16.03.	17.03.	18.03.
Flue gas temperature	°C	134,3	136,0	135,2
Flue gas humidity	g/m <sup>3</sup> (std)	172	179	165
Flue gas humidity	Vol.-%	17,6	18,2	17,1
Barometric pressure	hPa	1007	995	996
Dynamic pressure	hPa	-31,5	-30,3	-29,8
Content CO <sub>2</sub>	Vol.-%	10,7	10,95	10,71
Content O <sub>2</sub>	Vol.-%	8,38	8,14	8,21
Flue gas velocity	m/s	11,8	12,2	11,6
Flue gas volumetric flow rate V <sub>O</sub>	m <sup>3</sup> /h (p,t,h)	65.543	67.423	64.333
Flue gas volumetric flow rate V <sub>std, h</sub>	m <sup>3</sup> /h (std,h)	42.824	42.640	41.192
Flue gas volumetric flow rate V <sub>std</sub>	m <sup>3</sup> /h (std)	35.276	34.874	34.176

wheras

p,t,h = data referred to operating conditions

std,h = data referred to standard conditions and humid gas

std = data referred to standard conditions of dried gas

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## 6.2.2 Results of the emission measurements

- measuring component: Polychlorinated dibenzodioxins and dibenzofurans (PCDD/F)
- Emission limit: 0,1 ng I-TEQ/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [ng/m <sup>3</sup> *)	Emitted mass flow M [µg/h]
16.03.	10:15-16:20	8,38	<0,001	0,005
17.03.	09:30-15:35	8,14	<0,001	0,002
18.03.	09:15-15:20	8,21	<0,001	0,001
Maximum value		-	<0,001	0,005
Mean value		-	<0,001	0,003

\*) referred to reference oxygen content of 11 vol -%

- measuring component: Hydrogen fluoride (HF)
- Emission limit 24-hourly mean value: 1 mg/m<sup>3</sup>
- half-hourly mean value: 4 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> *)	Emitted mass flow M [kg/h]
17.03.	09:30-11:00	8,26	≤ 0,1	≤ 0,005
17.03.	11:15-12:45	8,10	≤ 0,1	≤ 0,004
17.03.	13:00-14:30	8,06	≤ 0,1	≤ 0,004
17.03.	14:45-16:15	8,13	≤ 0,1	≤ 0,005
Maximum value		-	≤ 0,1	≤ 0,005
Mean value		-	≤ 0,1	≤ 0,005

\*) referred to reference oxygen content of 11 vol -%

- measuring component: Hydrogen chloride (HCl)
- Emission limit 24-hourly mean value: 10 mg/m<sup>3</sup>
- half-hourly mean value: 60 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> *)	Emitted mass flow M [kg/h]
18.03.	09:15-10:45	8,06	0,8	0,033
18.03.	11:00-12:30	8,09	1,1	0,045
18.03.	12:45-14:15	8,36	1,4	0,061
18.03.	14:30-16:00	8,38	0,9	0,041
Maximum value		-	1,4	0,061
Mean value		-	1,0	0,045

\*) referred to reference oxygen content of 11 vol -%

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- measuring component: Sulfur oxides (SO<sub>2</sub>)  
 Emission limit 24-hourly mean value: 50 mg/m<sup>3</sup>  
 half-hourly mean value: 200 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
17.03.	09:30-11:00	8,26	20,2	0,894
17.03.	11:15-12:45	8,10	34,3	1,560
17.03.	13:00-14:30	8,06	36,6	1,669
17.03.	14:45-16:15	8,13	39,2	1,789
Maximum value		-	39,2	1,789
Mean value		-	32,6	1,478

\*) referred to reference oxygen content of 11 vol -%

- measuring component: Ammonia (NH<sub>3</sub>)  
 Emission limit 24-hourly mean value: 10 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
17.03.	09:30-11:00	8,26	1,1	0,049
17.03.	11:15-12:45	8,10	0,2	0,007
17.03.	13:00-14:30	8,06	0,1	0,006
17.03.	14:45-16:15	8,13	0,2	0,009
Maximum value		-	1,1	0,049
Mean value		-	0,4	0,018

\*) referred to reference oxygen content of 11 vol -%

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Environmental monitoring body registered in accordance with § 29 b BImSchG

- measuring component: Carbon monoxide (CO)  
Emission limit 24-hourly mean value: 50 mg/m<sup>3</sup>  
half-hourly mean value: 100 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
16.03.	10:15-10:45	8,44	1	0,084
16.03.	11:15-11:45	8,39	2	0,120
16.03.	12:15-12:45	8,19	4	0,220
16.03.	14:45-15:15	8,17	5	0,240
16.03.	15:45-16:15	8,39	3	0,140
17.03.	09:30-10:00	8,13	0	0,016
17.03.	10:30-11:00	8,38	0	<0,001
17.03.	11:30-12:00	8,02	0	0,013
17.03.	14:00-14:30	8,11	2	0,130
17.03.	15:00-15:30	7,99	6	0,300
18.03.	09:15-09:45	8,20	0	0,030
18.03.	10:15-10:45	8,07	0	0,032
18.03.	11:15-11:45	8,03	0	0,039
18.03.	13:45-14:15	8,20	0	0,035
18.03.	14:45-15:15	8,44	1	0,048
Maximum value		-	6	0,300
Mean value		-	1	0,103

\*) referred to reference oxygen content of 11 vol -%

- measuring component: Nitrogen monoxide (NO) and Nitrogen dioxide (NO<sub>2</sub>)  
Emission limit 24-hourly mean value: 200 mg/m<sup>3</sup>  
half-hourly mean value: 400 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
16.03.	10:15-10:45	8,44	201	9,200
16.03.	11:15-11:45	8,39	175	8,000
16.03.	12:15-12:45	8,19	141	6,300
16.03.	14:45-15:15	8,17	145	6,400
16.03.	15:45-16:15	8,39	190	8,300
17.03.	09:30-10:00	8,13	159	7,100
17.03.	10:30-11:00	8,38	186	8,200
17.03.	11:30-12:00	8,02	165	7,500
17.03.	14:00-14:30	8,11	145	6,600
17.03.	15:00-15:30	7,99	138	6,400
18.03.	09:15-09:45	8,20	170	7,200
18.03.	10:15-10:45	8,07	166	7,100
18.03.	11:15-11:45	8,03	146	6,200
18.03.	13:45-14:15	8,20	169	7,700
18.03.	14:45-15:15	8,44	212	9,400
Maximum value		-	212	9,400
Mean value		-	167	7,440

\*) referred to reference oxygen content of 11 vol -%

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- measuring component: Total organic carbon (TOC)  
 Emission limit 24-hourly mean value: 10 mg/m<sup>3</sup>  
 half-hourly mean value: 20 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
18.03.	09:15-09:45	8,20	< 1	0,002
18.03.	10:15-10:45	8,07	< 1	0,002
18.03.	11:15-11:45	8,03	< 1	0,002
18.03.	13:45-14:15	8,20	< 1	0,004
18.03.	14:45-15:15	8,44	< 1	0,005
Maximum value		-	< 1	0,005
Mean value		-	< 1	0,003

\*) referred to reference oxygen content of 11 vol -%

- measuring component: Total dust, including micro dust  
 Emission limit 24-hourly mean value: 10 mg/m<sup>3</sup>  
 half-hourly mean value: 30 mg/m<sup>3</sup>

Date 2016	Time period	Oxygen O <sub>M</sub> [Vol.-%]	Emission E <sub>B</sub> [mg/m <sup>3</sup> ] *)	Emitted mass flow M [kg/h]
17.03.	09:30-11:00	8,26	<0,1	<0,001
17.03.	11:15-12:45	8,10	<0,1	<0,001
17.03.	13:00-14:30	8,06	<0,1	<0,001
17.03.	14:45-16:15	8,13	<0,1	<0,001
Maximum value		-	<0,1	<0,001
Mean value		-	<0,1	<0,001

\*) referred to reference oxygen content of 11 vol -%

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 b BImSchG

- measuring component: Heavy Metals and Carcinogenic Substances

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Mercury	Hg				0,03
18.03.2017	09:15-10:45	8,06	<0,001	<0,0025	
18.03.2017	11:00-12:30	8,09	<0,001	<0,0042	
18.03.2017	12:45-14:15	8,36	<0,001	<0,0070	
18.03.2017	14:30-16:00	8,38	<0,001	<0,0066	
Maximum value		-	<0,001	<0,0070	
Mean value		-	<0,001	<0,0051	
Cadmium	Cd				
18.03.2017	09:15-10:45	8,06	<0,001	0,0001	
18.03.2017	11:00-12:30	8,09	<0,001	0,0001	
18.03.2017	12:45-14:15	8,36	<0,001	0,0002	
18.03.2017	14:30-16:00	8,38	<0,001	0,0002	
Thallium	Tl				
18.03.2017	09:15-10:45	8,06	<0,001	0,0006	
18.03.2017	11:00-12:30	8,09	<0,001	0,0007	
18.03.2017	12:45-14:15	8,36	<0,001	0,0009	
18.03.2017	14:30-16:00	8,38	<0,001	0,0008	
Antimony	Sb				
18.03.2017	09:15-10:45	8,06	<0,001	0,0023	
18.03.2017	11:00-12:30	8,09	<0,001	0,0108	
18.03.2017	12:45-14:15	8,36	<0,001	0,0034	
18.03.2017	14:30-16:00	8,38	<0,001	0,0030	
Arsenic	As				
18.03.2017	09:15-10:45	8,06	<0,001	0,0019	
18.03.2017	11:00-12:30	8,09	<0,001	0,0034	
18.03.2017	12:45-14:15	8,36	<0,001	0,0028	
18.03.2017	14:30-16:00	8,38	<0,001	0,0025	

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## ❖ Heavy metals

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Lead	Pb				
18.03.2017	09:15-10:45	8,06	0,002	0,0789	
18.03.2017	11:00-12:30	8,09	<0,001	0,0194	
18.03.2017	12:45-14:15	8,36	<0,001	0,0095	
18.03.2017	14:30-16:00	8,38	<0,001	0,0083	
Chromium	Cr				
18.03.2017	09:15-10:45	8,06	<0,001	0,0029	
18.03.2017	11:00-12:30	8,09	<0,001	0,0096	
18.03.2017	12:45-14:15	8,36	<0,001	0,0062	
18.03.2017	14:30-16:00	8,38	<0,001	0,0045	
Cobalt	Co				
18.03.2017	09:15-10:45	8,06	<0,001	0,0073	
18.03.2017	11:00-12:30	8,09	<0,001	0,0015	
18.03.2017	12:45-14:15	8,36	<0,001	0,0016	
18.03.2017	14:30-16:00	8,38	<0,001	0,0014	
Copper	Cu				
18.03.2017	09:15-10:45	8,06	<0,001	0,0072	
18.03.2017	11:00-12:30	8,09	0,001	0,0582	
18.03.2017	12:45-14:15	8,36	<0,001	0,0154	
18.03.2017	14:30-16:00	8,38	<0,001	0,0154	
Manganese	Mn				
18.03.2017	09:15-10:45	8,06	<0,001	0,0054	
18.03.2017	11:00-12:30	8,09	0,001	0,0232	
18.03.2017	12:45-14:15	8,36	0,002	0,0734	
18.03.2017	14:30-16:00	8,38	<0,001	0,0205	



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## ❖ Heavy metals

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Nickel	Ni				
18.03.2017	09:15-10:45	8,06	<0,001	0,0069	
18.03.2017	11:00-12:30	8,09	<0,001	0,0081	
18.03.2017	12:45-14:15	8,36	<0,001	0,0077	
18.03.2017	14:30-16:00	8,38	<0,001	0,0066	
Vanadium	V				
18.03.2017	09:15-10:45	8,06	<0,001	0,0039	
18.03.2017	11:00-12:30	8,09	<0,001	0,0055	
18.03.2017	12:45-14:15	8,36	<0,001	0,0060	
18.03.2017	14:30-16:00	8,38	<0,001	0,0052	
Tin	Sn				
18.03.2017	09:15-10:45	8,06	<0,001	0,0044	
18.03.2017	11:00-12:30	8,09	<0,001	0,0105	
18.03.2017	12:45-14:15	8,36	<0,001	0,0062	
18.03.2017	14:30-16:00	8,38	<0,001	0,0053	

## ❖ Carcinogenic Substances

Compound		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[µg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Benzo(a)pyrene	BaP				
16.03.2017	10:15-16:20	8,38	< 1	< 1	
17.03.2017	09:30-15:35	8,14	< 1	< 1	
18.03.2017	09:15-15:20	8,21	< 1	< 1	

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## ❖ Heavy metals: Cadmium and Thallium Cd + Tl

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Σ Cd, Tl					0,05
13.10.2016	09:20-10:50	7,88	<0,001	0,0007	
13.10.2016	11:05-12:35	7,72	<0,001	0,0009	
13.10.2016	12:45-14:15	7,62	<0,001	0,0010	
13.10.2016	14:25-15:55	7,81	<0,001	0,0009	
Maximum value		-	<0,001	0,0010	
Mean value		-	<0,001	0,0009	

## ❖ Heavy metals: Antimony to Tin (Sb to Sn) Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Σ Sb,As,Pb,Cr,Co,Cu,Mn,Ni,V,Sn					0,5
13.10.2016	09:20-10:50	7,88	0,003	0,1211	
13.10.2016	11:05-12:35	7,72	0,004	0,1501	
13.10.2016	12:45-14:15	7,62	0,003	0,1321	
13.10.2016	14:25-15:55	7,81	0,002	0,0727	
Maximum value		-	0,004	0,1501	
Mean value		-	0,003	0,1190	

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## ❖ Carcinogenic Substances: Arsenic to Chromium (As bis Cr) As, Benzo(a)pyrene, Cd, Co, Cr

Metal		Oxygen O <sub>M</sub>	Emission E <sub>B</sub>	Emitted mass flow M	Emission limit
Date	Time period	[Vol.-%]	[mg/m <sup>3</sup> ]	[g/h]	[mg/m <sup>3</sup> ]
Σ As, BaP, Cd, Co, Cr					0,05
13.10.2016	09:20-10:50	7,88	<0,001	0,0155	
13.10.2016	11:05-12:35	7,72	<0,001	0,0179	
13.10.2016	12:45-14:15	7,62	<0,001	0,0144	
13.10.2016	14:25-15:55	7,81	<0,001	0,0120	
Maximum value		-	<0,001	0,0179	
Mean value		-	<0,001	0,0150	

### 6.3 Measurement uncertainties

For the assessment of the outcome of the measurements the uncertainties, resulting from unavoidable error effects of sampling, sample preparation and from the measuring instruments tolerance are to be considered. The expanded uncertainties (U<sub>p</sub>) were determined as described in our QMH (QSV 00420) procedure for the indirect approach (in accordance with VDI 4219 and EN ISO 20988, confidence level 95 %) or by direct approach in the framework of our method verification.

Measured component	Maximum result y <sub>max</sub>	expanded uncertainty (U <sub>p</sub> )	y <sub>max</sub> - U <sub>p</sub>	y <sub>max</sub> + U <sub>p</sub>	Method of Determina- tion
Cd + Tl [mg/m <sup>3</sup> ]	<0,001	<0,001	<0,01	<0,01	indirekt
Sb to Sn [mg/m <sup>3</sup> ]	0,004	0,001	<0,01	<0,01	indirekt
As to Cr [mg/m <sup>3</sup> ]	<0,001	<0,001	<0,01	<0,01	indirekt
Hg [mg/m <sup>3</sup> ]	<0,001	<0,001	<0,01	<0,01	indirekt
PCDD/F [ngTE/m <sup>3</sup> ]	<0,001	<0,001	<0,1	<0,1	indirekt
HF [mg/m <sup>3</sup> ]	<0,1	<0,1	<1	<1	indirekt
HCl [mg/m <sup>3</sup> ]	1,4	0,1	1	2	direkt
Total dust [mg/m <sup>3</sup> ]	<0,1	0,02	<1	<1	indirekt
SO <sub>2</sub> [mg/m <sup>3</sup> ]	39,2	3,6	36	43	direkt
NH <sub>3</sub> [mg/m <sup>3</sup> ]	1,1	0,1	1	1	indirekt
TOC [mg/m <sup>3</sup> ]	<1,0	2,0	0	<3	direkt
CO [mg/m <sup>3</sup> ]	6,0	2,2	4	8	direkt
NO <sub>2</sub> [mg/m <sup>3</sup> ]	212,0	5,5	207	218	direkt

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## 6.4 Plausibility check

The outcome of the measurements is in the expected range of recent measurements and is typical for the systems engineering and operation. Critical review has shown that the values are to be considered as plausible.

## TÜV NORD Umweltschutz GmbH & Co. KG

The authorised Expert

Specialist person in charge /  
Technical Responsibility  
(Temporary position)



W. Vortherms

Dipl.-Ing. T. Kalbach

## 7 Appendix – overview attachments

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Kriterien für O <sub>2</sub> -Messgeräte nach DIN EN 14789 (grundsätzliche Eignung)										Unsicherheitsbilanz				
Messgerät QS-Nr.	81360055			Kriterium			spezifische Gerätekenngößen, Labor- u. Feldtest und Eignungsprüfung					eingehalten	resultierende Unsicherheit u <sub>c</sub>	Erläuterung
Hersteller	Emerson Process Ma			Wert	relativ	absolut [Vol.-%]	Wert relativ	absolut						
Typ	NGA 2000 MLT 4.4													
Messbereich	25,0 Vol.-%													
letzte Prüfung	09.02.2017													
Leistungskenngröße	Labor	Feld		Wert	relativ	absolut [Vol.-%]	Wert relativ	absolut						
Einstellzeit	x	x		200		s		60	s (Labor)		ja			
Nachweisgrenze	x			0,20	% MB	0,20		0,120	Vol.-%		ja	ohne Bewertung		
Abweichung Linearität	x			0,30	± Vol.-%	0,30		0,010	Vol.-%		ja			
Nullpunktdrift	x	x		0,20	± Vol.-% / 24 h	0,20	-0,021	± Vol.-% / 24 h		ja				
Referenzpunktdrift	x	x		0,20	± Vol.-% / 24 h	0,2	-0,129	± Vol.-% / 24 h		ja				
Empf. gegen Luftdruck	x			3	± % MB / 2 kPa	0,75	0,000	± Vol.-% / kPa		ja				
Empf. f(Probegasdurchfluss/-druck)	x			-	Herstellervorgaben	-	0,000	± Vol.-% / (l/h)		ja				
NP-Empf. f(Umgebungstemperatur)	x			0,30	± Vol.-% / 10 K	0,30	-0,001	± Vol.-% / K		ja				
RP-Empf. f(Umgebungstemperatur)	x			0,30	± Vol.-% / 10 K	0,30	0,006	± Vol.-% / K		ja				
Empf. f(Netzspannung)	x			0,10	± Vol.-% / 10 Volt	0,10	0,000	± Vol.-% / Volt		ja				
Querempfindlichkeit CO <sub>2</sub>	x						0,001	Vol.-% / Vol.-%						
Querempfindlichkeit H <sub>2</sub> O	x						0,031	Vol.-% / Vol.-%						
Querempfindlichkeit NO	x						0,0001	Vol.-% / mg/m <sup>3</sup>						
Querempfindlichkeit NO <sub>2</sub>	x						0,0000	Vol.-% / mg/m <sup>3</sup>						
Störkomponenten positiv	x			0,2	Vol.-%	0,2	-	Vol.-%		0,08	Vol.-%	ja	Bei den Schwankungsbreiten der Störgrößen wird eine Maximalwertbetrachtung durchgeführt. Unter Umständen ist eine Minimierung der Störgrößen (z.B. Klimatisierung / kürzere Justageintervalle) mit Einzelfallbeurteilung erforderlich. Die Einzelfallbeurteilung erfolgt automatisch für jede Einzelprobe im Auswertblatt.	
Störkomponenten negativ	x			0,2	Vol.-%	0,2	-	Vol.-%		0,00	Vol.-%	ja		
Verluste und Undichtigkeiten		x		2	% MW	-	-	% MW				ja		
Stabw. Wiederholpräzision Nullpunkt	x			0,20	% MB	0,05	-	% MB		0,006	Vol.-%	ja		
Stabw. Wiederholpräzision Referenzpunkt	x			0,40	% MB	0,10	-	% MB		0,006	Vol.-%	ja		
Prüfgastoleranz							0,2 % rel.	Bezugswert		11,00	Vol.-%	ja		
Leistungskenngröße	Schwankungsbereich der Störgröße						Querempfindlichkeit		negativ	positiv		0,10 Vol.-%		Unsicherheit u <sub>c</sub>
Luftdruck	4	kPa	EIG				Konz. d. Störgrößen gemäß Tabelle 2			0,015		0,19 Vol.-%		Unsicherheit U <sub>0,95</sub>
Umgebungstemperatur	35	°C	EIG				DIN EN 14789			0,031		Einhaltung der Vorgabe gemäß Nr. 7.1 DIN EN 14789		
elektrische Betriebsspannung 230 Volt	60	Volt	EIG							0,03				
CO <sub>2</sub> (jährliche Prüfmittelüberwachung)	16,0	Vol.-%	PMÜ											
H <sub>2</sub> O (jährliche Prüfmittelüberwachung)	1,0	Vol.-%	PMÜ											
NO (jährliche Prüfmittelüberwachung)	268,9	mg/m <sup>3</sup>	PMÜ											
NO <sub>2</sub> (jährliche Prüfmittelüberwachung)	165,7	mg/m <sup>3</sup>	PMÜ				Summe (Vol.-%)		0,00	0,08				

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG



Kriterien für CO-Messgeräte nach DIN EN 15058 (grundsätzliche Eignung)												
Messgerät QS-Nr.	81360055											
Hersteller	Emerson Process Man											
Typ	NGA 2000 MLT 4											
Messbereich	625,5 mg/m³											
letzte Prüfung	09.02.2017											
Leistungskenngröße	Labor	Feld	Kriterium			spezifische Gerätekenngößen, Labor- u. Feldtest und Eignungsprüfung				Unsicherheitsbilanz		
			Wert	relativ	absolut [mg/m³]	Wert relativ		absolut		eingehalten	resultierende Unsicherheit uc	Erläuterung
Einstellzeit	x	x	200		s			60	s (Labor)			
Nachweisgrenze	x		2	± % MB	12,51			1,19	mg/m³	ja		
Abweichung Linearität	x		2	± % MB	12,51			0,2979735	mg/m³	ja	0,17 mg/m³	
Nullpunktdrift	x		2	± % MB / 24 h	12,51			-0,4576829	mg/m³	ja	-0,26 mg/m³	
Referenzpunktdrift	x		2	± % MB / 24 h	12,51			-4,1191463	mg/m³	ja	-2,38 mg/m³	
Empfindlichkeit gegen Luftdruck	x		3	± % MB / 2 kPa	18,765	0,0000	± mg/m³ / kPa	0,0	mg/m³	ja	0,00 mg/m³	
Empfindlichkeit f(Probegasdurchfluss/-druck)	x		-	Herstellervorgaben	-	0,0000	± mg/m³ / (l/h)	0,00	mg/m³ (bei ± 10 l/h)	ja	0,00 mg/m³	
NP-Empfindlichkeit f(Umgebungstemperatur)	x		3	± % MB / 10 K	18,765	0,0234	± mg/m³ / K	0,23	mg/m³	ja	0,14 mg/m³	
RP-Empfindlichkeit f(Umgebungstemperatur)	x		3	± % MB / 10 K	18,765	0,0188	± mg/m³ / K	0,19	mg/m³	ja	0,14 mg/m³	
Empfindlichkeit f(Netzspannung)	x		2	± % MB / 10 Volt	12,51	0,0000	± mg / Volt	0,00	mg/m³	ja	0,00 mg/m³	
Querempfindlichkeit CO <sub>2</sub>	x					0,06	mg/m³ / Vol.-%	0,94	mg/m³			
Querempfindlichkeit H <sub>2</sub> O	x					3,28	mg/m³ / Vol.-%	3,28	mg/m³			
Querempfindlichkeit N <sub>2</sub> O	x					0,003	mg/m³ / mg/m³	0,78	mg/m³			
Querempfindlichkeit CH <sub>4</sub>	x					0,000	mg/m³ / mg/m³	0,00	mg/m³			
Störkomponenten positiv	x		4	% MB	25,02	-	% MB	0,7	% MB	ja	0,39 mg/m³	
Störkomponenten negativ	x		4	% MB	25,02	-	% MB	0,00	% MB	ja	0,39 mg/m³	
Verluste und Undichtigkeiten		x	2	% MW	-	-	% MW			ja	0,00 mg/m³	
Stabw. Wiederholpräzision Nullpunkt	x		1	% MB	6,255	-	% MB	0,13	mg/m³	ja	0,09 Vol.-%	
Stabw. Wiederholpräzision Referenzpunkt	x		2	% MB	12,51	-	% MB	0,16	mg/m³	ja	0,09 Vol.-%	
Prüfgastoleranz						2,0 % rel.	Grenzwert	100,00	mg/m³		1,00 mg/m³	
Leistungskenngröße	Schwankungsbereich der Störgröße					Querempfindlichkeiten		negativ	positiv		3,4 mg/m³	Unsicherheit U <sub>c</sub>
Luftdruck	4	kPa	EIG			Konz. d. Störgrößen gemäß Tabelle 2			0,880	<b>bedingt</b>	6,9 mg/m³	Unsicherheit U <sub>0,95</sub>
Umgebungstemperatur (5 bis 40 °C)	35	°C	EIG			DIN EN 15058			3,284	Einhaltung der Vorgabe gemäß Nr. 7.1 DIN EN 15058	Prüfen, ob MB verkleinert werden kann bzw. Störgrößen minimiert werden können z.B. Umgebungstemp. konstant halten oder Neujustage bei Luftdruckschwankung	
elektrische Betriebsspannung 230 Volt	60	Volt	EIG						0,100			
CO <sub>2</sub> (jährliche Prüfmittelüberwachung)	16,0	Vol.-%	PMÜ			Summe (mg/m³)		<b>0,00</b>	<b>4,3</b>	nein		
H <sub>2</sub> O (jährliche Prüfmittelüberwachung)	1,0	Vol.-%	PMÜ									
N <sub>2</sub> O (jährliche Prüfmittelüberwachung)	312,3	mg/m³	PMÜ									
CH <sub>4</sub> (jährliche Prüfmittelüberwachung)	57,3516	mg/m³	PMÜ									

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG



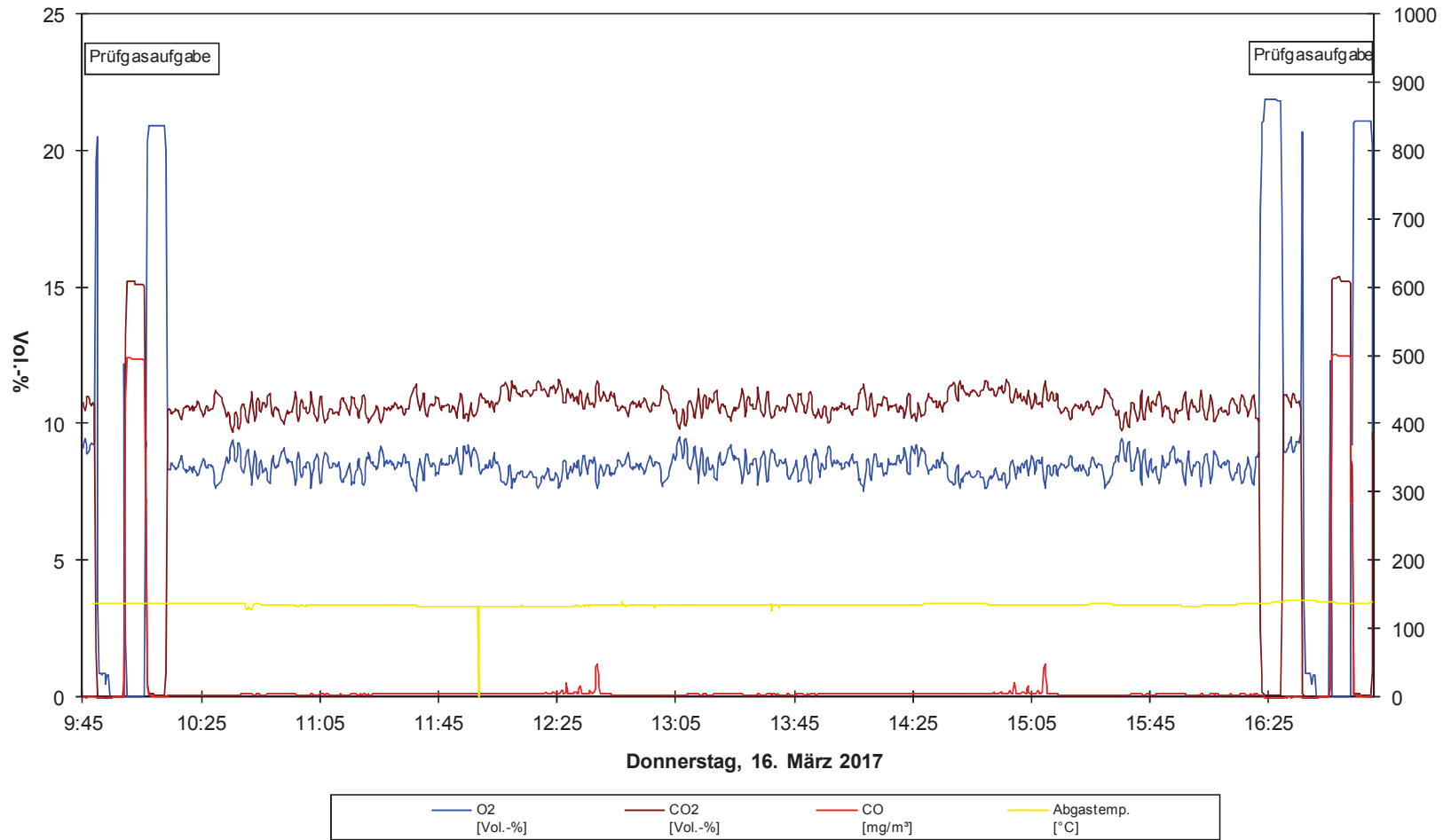
Kriterien für NOx (als NO <sub>2</sub> )-Messgeräte nach DIN EN 14792 (grundsätzliche Eignung)										Unsicherheitsbilanz		
Messgerät QS-Nr.	81360055											
Hersteller	Emerson Process M											
Typ	NGA 2000 CLD											
Messbereich	512,5 mg/m <sup>3</sup>											
letzte Prüfung	09.02.2017											
Leistungskenngröße	Labor	Feld	Kriterium			spezifische Gerätekenngößen, Labor- u. Feldtest und Eignungsprüfung			eingehalten	resultierende Unsicherheit uc	Erläuterung	
			Wert	relativ	absolut [mg/m <sup>3</sup> ]	Wert relativ	absolut	s (Labor)				
Einstellzeit	x	x	200		s			60	ja			
Nachweisgrenze	x		2	± % MB	10,3			4,926	ja		ohne Bewertung	
Abweichung Linearität	x		2	± % MB	10,3			0,23	ja			
Nullpunktdrift	x		2	± % MB / 24 h	10,3			-0,304455	ja			
Referenzpunktdrift	x		2	± % MB / 24 h	10,3			-3,04	ja			
Empfindlichkeit gegen Luftdruck	x		3	± % MB / 2 kPa	15,4	0,00	± mg/m <sup>3</sup> / kPa	0,0	ja			
Empfindlichkeit f(Probegasdurchfluss/-druck)	x		-	Herstellervorgaben	-	0,00	± mg/m <sup>3</sup> / (l/h)	0	ja		Bei den Schwankungsbreiten der Störgrößen wird eine Maximalwertbetragung durchgeführt.	
NP-Empfindlichkeit f(Umgebungstemperatur)	x		3	± % MB / 10 K	15,4	-0,53	± mg/m <sup>3</sup> / K	-5,3	ja			
RP-Empfindlichkeit f(Umgebungstemperatur)	x		3	± % MB / 10 K	15,4	-0,31	± mg/m <sup>3</sup> / K	-3,1	ja			
Empfindlichkeit f(Netzspannung)	x		2	± % MB / 10 Volt	10,3	0,00	± mg / Volt	0,0	ja		Unter Umständen ist eine	
Querempfindlichkeit CO <sub>2</sub>	x					0,02	mg/m <sup>3</sup> / Vol.-%	0,25625			Minimierung der Störgrößen (z.B. Klimatisierung / kürzere Justageintervalle) mit Einzelfallbeurteilung erforderlich.	
Querempfindlichkeit H <sub>2</sub> O	x					0,00	mg/m <sup>3</sup> / Vol.-%	0				
Querempfindlichkeit NH <sub>3</sub>	x					0	mg/m <sup>3</sup> / mg/m <sup>3</sup>	0				
Querempfindlichkeit SO <sub>2</sub>	x					0,000	mg/m <sup>3</sup> / mg/m <sup>3</sup>	0,128125				
Störkomponenten positiv	x		4	% MB	20,5	-	% MB	0,07	% MB	ja	0,04 mg/m <sup>3</sup>	Die Einzelfallbeurteilung erfolgt automatisch für jede Einzelprobe im Auswertblatt.
Störkomponenten negativ	x		4	% MB	20,5	-	% MB	0	% MB	ja		
Verluste und Undichtigkeiten			2	% MW	-	-	% MW			ja	0,00 mg/m <sup>3</sup>	
Stabw. Wiederholpräzision Nullpunkt	x		1	% MB	5,125	-	% MB	0,28	mg/m <sup>3</sup>	ja	0,16 Vol.-%	
Stabw. Wiederholpräzision Referenzpunkt	x		2	% MB	10,25	-	% MB	0,19	mg/m <sup>3</sup>	ja		
Prüfgastoleranz						2,0 % rel.	Grenzwert	400,00	mg/m <sup>3</sup>		4,00 mg/m <sup>3</sup>	
Leistungskenngröße	Schwankungsbereich der Störgröße					Querempfindlichkeiten		negativ	positiv		5,0 mg/m <sup>3</sup>	Unsicherheit U <sub>c</sub>
Luftdruck	2	kPa	EIG			Konz. d. Störgrößen gemäß Tabelle 2 DIN EN 14792			0,240	ja	10,1 mg/m <sup>3</sup>	Unsicherheit U <sub>0,95</sub>
Umgebungstemperatur (5 bis 40 °C)	35	°C	EIG							Einhaltung der Vorgabe gemäß Nr. 7.1 DIN EN 14792		
elektrische Betriebsspannung 230 Volt	40	Volt	EIG									
CO <sub>2</sub> (jährliche Prüfmittelüberwachung)	16	Vol.-%	PMÜ						0,128			
H <sub>2</sub> O (jährliche Prüfmittelüberwachung)	1	Vol.-%	PMÜ									
NH <sub>3</sub> (jährliche Prüfmittelüberwachung)	384,56	mg/m <sup>3</sup>	PMÜ			Summe (mg/m <sup>3</sup> )		0,00	0,37	ja		
SO <sub>2</sub> (jährliche Prüfmittelüberwachung)	455,3	mg/m <sup>3</sup>	PMÜ									



# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

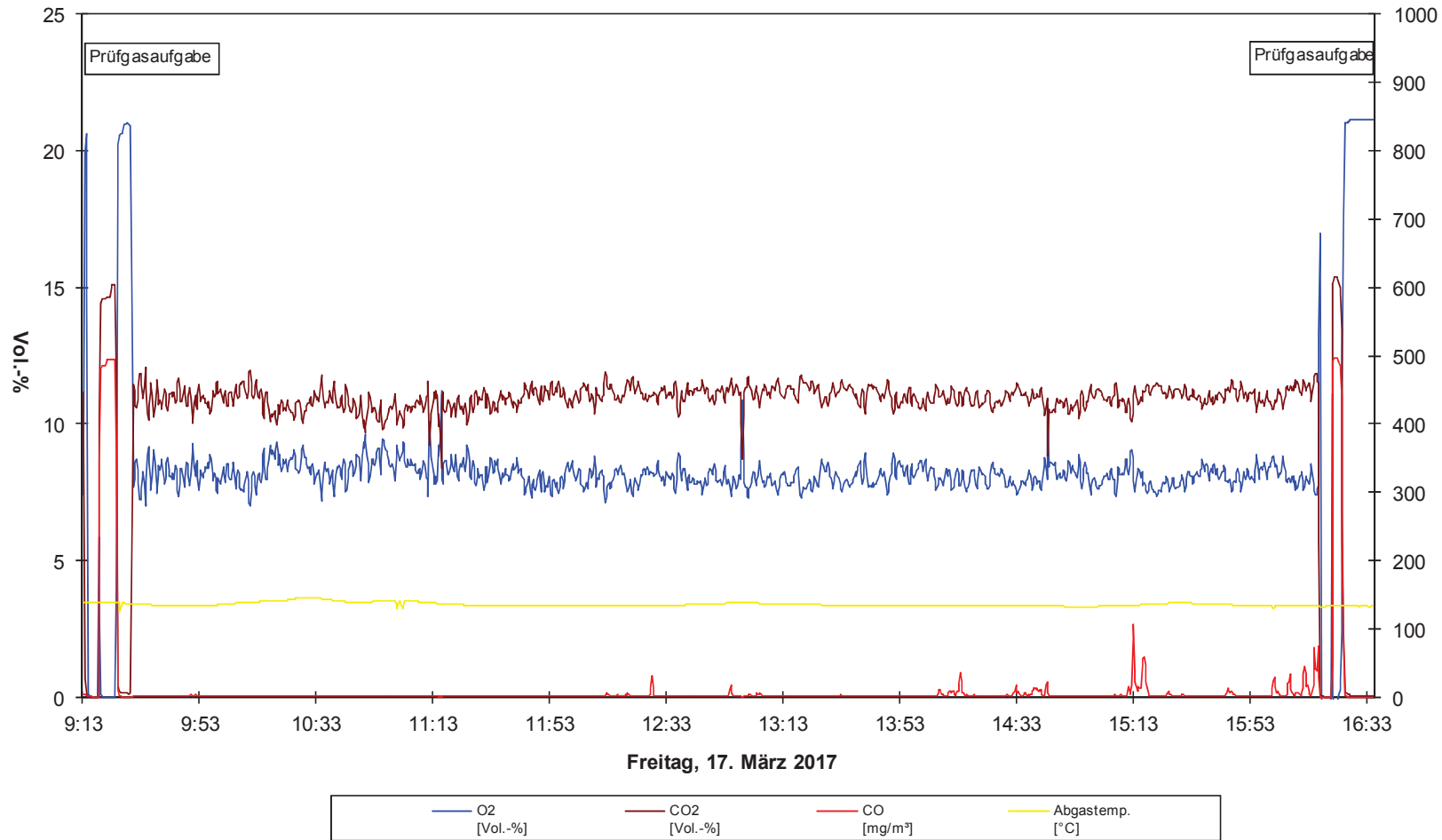
## Forus Energigjenvinning, Linie 2



# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

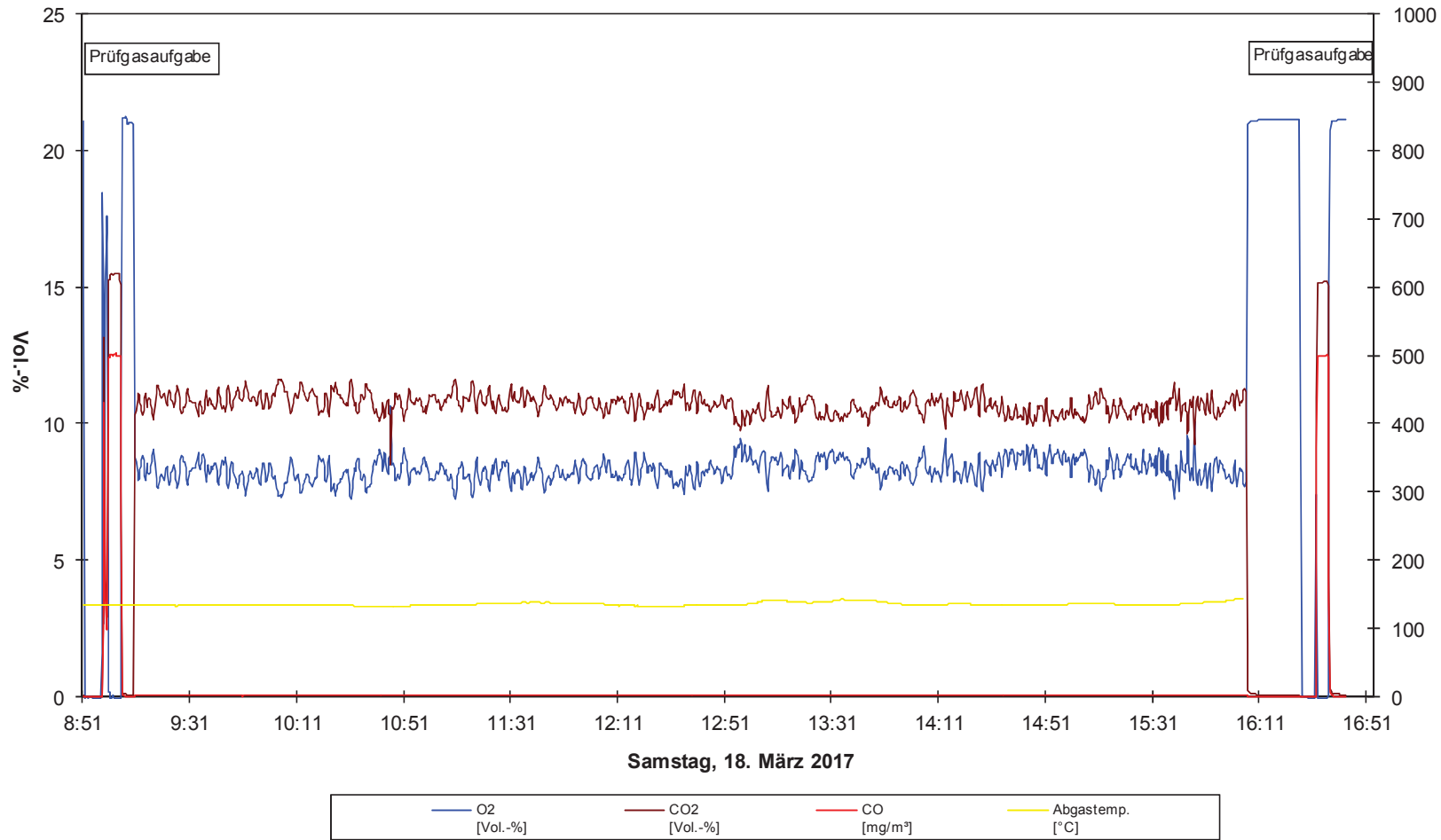
## Forus Energigjenvinning, Linie 2



# TÜV NORD Umweltschutz


Environmental monitoring body registered in accordance with § 29 BImSchG

## Forus Energigjenvinning, Linie 2




# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	16.03.2017 / 10:10			Sachverständiger:			Wilhelm Vortherms (TÜV NORD)
Luftdruck	[mbar]	1.010,0	u= 0,4	Absolutdruck Kanal		[mbar]	978,0
Differenzdruck Kanal/Umgebung	[mbar]	-32,0	u= 0,0	Dichte Betriebszustand		[kg/m³]	0,8179
Abgastemperatur	[°C]	130,1	u= 1,3	Dichte Normzustand, feucht		[kg/m³]	1,2510
Sauerstoffgehalt	[Vol.-%]	8,3	u= 0,13	Dichte Normzustand, trocken		[kg/m³]	1,3467
Kohlendioxidgehalt	[Vol.-%]	10,5	u= 0,25	Wasserdampfgehalt		[Vol.-%]	17,6
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit		[m/s]	12,8
Gasfeuchte	[g/m³]	172,0	u= 4,7	min. lokale Geschwindigkeit		[m/s]	11,6
Staurohrfaktor	□	1,00		Verhältnis max/min			1,1
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:	2			Messpunkte je Achse:		4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		56,4	62,5	67,2	57,4		
Messwerte	[m/s]	11,7	12,4	12,8	11,9		
Achse 2, [Pa]		58,0	65,5	64,2	55,3		
Messwerte	[m/s]	11,9	12,7	12,5	11,6		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	60,7	U (0,95) absolut		U (0,95) relativ	eff. Freiheitsgrade	
mittlere Gasgeschwindigkeit	[m/s]	12,2	± 0,3		2,4 %	4	
Volumenstrom, Betriebszustand	[m³/h]	67.540	± 1.735		2,6 %	8	
Volumenstrom, Normzustand, feucht	[m³/h]	44.158	± 1.158		2,6 %	9	
Volumenstrom, Normzustand, trocken	[m³/h]	36.375	± 1.162		3,2 %	27	
Volumenstrom im Bezugszustand	[m³/h]	46.196	Bezugs-Sauerstoffgehalt:			11,0	


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
<b>Betreiber:</b>	Forus Energigjenvinning						
<b>Anlage:</b>	Linie 2						
<b>Messquerschnitt:</b>	Abgaskanal						
<b>Betriebszustand:</b>	I = Regelbetrieb						
<b>Bemerkungen:</b>	keine						
<b>Datum/Uhrzeit</b>	16.03.2017 / 11:25			Sachverständiger: Wilhelm Vortherms (TÜV NORD)			
Luftdruck	[mbar]	1.008,0	u= 0,4	Absolutdruck Kanal	[mbar]	977,0	
Differenzdruck Kanal/Umgebung	[mbar]	-31,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,8276	
Abgastemperatur	[°C]	124,7	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2501	
Sauerstoffgehalt	[Vol.-%]	8,9	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3457	
Kohlendioxidgehalt	[Vol.-%]	10,2	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,6	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,0	
Gasfeuchte	[g/m³]	172,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,0	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
<b>Wandabstände</b>	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		56,0	59,0	59,7	53,0		
Messwerte	[m/s]	11,6	11,9	12,0	11,3		
Achse 2, [Pa]		49,7	56,5	54,2	52,9		
Messwerte	[m/s]	11,0	11,7	11,4	11,3		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	55,1	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	11,5	± 0,3	2,5 %	4		
Volumenstrom, Betriebszustand	[m³/h]	63.938	± 1.698	2,7 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	42.327	± 1.146	2,7 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	34.866	± 1.138	3,3 %	25		
Volumenstrom im Bezugszustand	[m³/h]	42.084	Bezugs-Sauerstoffgehalt:			11,0	


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	16.03.2017 / 14:00		Sachverständiger: Wilhelm Vortherms (TÜV NORD)				
Luftdruck	[mbar]	1.007,0	u= 0,4	Absolutdruck Kanal	[mbar]	975,5	
Differenzdruck Kanal/Umgebung	[mbar]	-31,5	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,8067	
Abgastemperatur	[°C]	134,9	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2517	
Sauerstoffgehalt	[Vol.-%]	8,6	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3476	
Kohlendioxidgehalt	[Vol.-%]	10,6	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,6	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,1	
Gasfeuchte	[g/m³]	172,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,4	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:	2		Messpunkte je Achse:			4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		54,6	57,8	59,4	56,0		
Messwerte	[m/s]	11,6	12,0	12,1	11,8		
Achse 2, [Pa]		52,8	54,9	56,4	54,2		
Messwerte	[m/s]	11,4	11,7	11,8	11,6		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	55,7	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	11,8	± 0,3	2,5 %	4		
Volumenstrom, Betriebszustand	[m³/h]	65.150	± 1.710	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	41.987	± 1.122	2,7 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	34.586	± 1.120	3,2 %	25		
Volumenstrom im Bezugszustand	[m³/h]	42.956	Bezugs-Sauerstoffgehalt:		11,0		


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	17.03.2017 /9:25			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	995,0	u= 0,4	Absolutdruck Kanal	[mbar]	964,0	
Differenzdruck Kanal/Umgebung	[mbar]	-31,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,7888	
Abgastemperatur	[°C]	138,0	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2480	
Sauerstoffgehalt	[Vol.-%]	8,8	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3470	
Kohlendioxidgehalt	[Vol.-%]	10,4	u= 0,25	Wasserdampfgehalt	[Vol.-%]	18,2	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,6	
Gasfeuchte	[g/m³]	179,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,8	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		54,9	57,7	60,9	54,9		
Messwerte	[m/s]	11,8	12,1	12,4	11,8		
Achse 2, [Pa]		57,1	62,6	60,6	55,9		
Messwerte	[m/s]	12,0	12,6	12,4	11,9		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	58,1		U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade	
mittlere Gasgeschwindigkeit	[m/s]	12,1		± 0,3	2,4 %	4	
Volumenstrom, Betriebszustand	[m³/h]	67.236		± 1.732	2,6 %	8	
Volumenstrom, Normzustand, feucht	[m³/h]	42.497		± 1.116	2,6 %	9	
Volumenstrom, Normzustand, trocken	[m³/h]	34.757		± 1.121	3,2 %	27	
Volumenstrom im Bezugzustand	[m³/h]	42.369		Bezugs-Sauerstoffgehalt:		11,0	

# TÜV NORD Umweltschutz


Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	17.03.2017 / 11:10			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	995,0	u= 0,4	Absolutdruck Kanal	[mbar]	964,0	
Differenzdruck Kanal/Umgebung	[mbar]	-31,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,7871	
Abgastemperatur	[°C]	139,1	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2486	
Sauerstoffgehalt	[Vol.-%]	8,5	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3476	
Kohlendioxidgehalt	[Vol.-%]	10,6	u= 0,25	Wasserdampfgehalt	[Vol.-%]	18,2	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,7	
Gasfeuchte	[g/m³]	179,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,9	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		57,6	62,5	63,5	60,5		
Messwerte	[m/s]	12,1	12,6	12,7	12,4		
Achse 2, [Pa]		55,7	61,5	60,5	57,1		
Messwerte	[m/s]	11,9	12,5	12,4	12,1		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	59,8	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	12,3	± 0,3	2,3 %	4		
Volumenstrom, Betriebszustand	[m³/h]	68.337	± 1.744	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	43.078	± 1.121	2,6 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	35.232	± 1.129	3,2 %	28		
Volumenstrom im Bezugzustand	[m³/h]	43.935	Bezugs-Sauerstoffgehalt:		11,0		




# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	17.03.2017 /12:55			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	995,0	u= 0,4	Absolutdruck Kanal	[mbar]	967,0	
Differenzdruck Kanal/Umgebung	[mbar]	-28,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,7930	
Abgastemperatur	[°C]	138,9	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2535	
Sauerstoffgehalt	[Vol.-%]	7,4	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3537	
Kohlendioxidgehalt	[Vol.-%]	11,7	u= 0,25	Wasserdampfgehalt	[Vol.-%]	18,2	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,6	
Gasfeuchte	[g/m³]	179,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,9	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
<b>Wandabstände</b>	[m]	<b>0,09</b>	<b>0,35</b>	<b>1,05</b>	<b>1,31</b>		
Achse 1, [Pa]		56,1	61,0	63,4	61,0		
Messwerte	[m/s]	11,9	12,4	12,6	12,4		
Achse 2, [Pa]		57,4	61,3	63,3	56,9		
Messwerte	[m/s]	12,0	12,4	12,6	12,0		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	60,0	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	12,3	± 0,3	2,3 %	4		
Volumenstrom, Betriebszustand	[m³/h]	68.164	± 1.742	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	43.124	± 1.124	2,6 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	35.269	± 1.131	3,2 %	28		
Volumenstrom im Bezugzustand	[m³/h]	48.107	Bezugs-Sauerstoffgehalt:		11,0		


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Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	17.03.2017 /14:35			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	995,0	u= 0,4	Absolutdruck Kanal	[mbar]	964,0	
Differenzdruck Kanal/Umgebung	[mbar]	-31,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,7941	
Abgastemperatur	[°C]	136,3	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2511	
Sauerstoffgehalt	[Vol.-%]	7,8	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3507	
Kohlendioxidgehalt	[Vol.-%]	11,2	u= 0,25	Wasserdampfgehalt	[Vol.-%]	18,2	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,3	
Gasfeuchte	[g/m³]	179,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,6	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		53,4	56,7	55,7	53,1		
Messwerte	[m/s]	11,6	12,0	11,8	11,6		
Achse 2, [Pa]		56,0	60,2	59,1	55,8		
Messwerte	[m/s]	11,9	12,3	12,2	11,9		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	56,2	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	11,9	± 0,3	2,4 %	4		
Volumenstrom, Betriebszustand	[m³/h]	65.954	± 1.719	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	41.860	± 1.111	2,7 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	34.236	± 1.111	3,2 %	27		
Volumenstrom im Bezugzustand	[m³/h]	45.123	Bezugs-Sauerstoffgehalt:		11,0		


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	18.03.2017 9:10		Sachverständiger: Wilhelm Vortherms (TÜV NORD)				
Luftdruck	[mbar]	994,0	u= 0,4	Absolutdruck Kanal	[mbar]	967,0	
Differenzdruck Kanal/Umgebung	[mbar]	-27,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,8024	
Abgastemperatur	[°C]	134,2	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2539	
Sauerstoffgehalt	[Vol.-%]	8,8	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3463	
Kohlendioxidgehalt	[Vol.-%]	10,3	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,0	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	11,8	
Gasfeuchte	[g/m³]	165,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	10,8	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:	2		Messpunkte je Achse:			4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		46,8	49,9	51,1	47,9		
Messwerte	[m/s]	10,8	11,2	11,3	10,9		
Achse 2, [Pa]		52,0	53,4	56,2	50,5		
Messwerte	[m/s]	11,4	11,5	11,8	11,2		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	50,9	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	11,3	± 0,3	2,6 %	4		
Volumenstrom, Betriebszustand	[m³/h]	62.449	± 1.683	2,7 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	39.964	± 1.095	2,7 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	33.157	± 1.084	3,3 %	23		
Volumenstrom im Bezugszustand	[m³/h]	40.618	Bezugs-Sauerstoffgehalt:		11,0		


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	18.03.2017 /10:45			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	996,0	u= 0,4	Absolutdruck Kanal	[mbar]	967,0	
Differenzdruck Kanal/Umgebung	[mbar]	-29,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,8077	
Abgastemperatur	[°C]	132,2	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2560	
Sauerstoffgehalt	[Vol.-%]	8,3	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3488	
Kohlendioxidgehalt	[Vol.-%]	10,8	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,0	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	11,5	
Gasfeuchte	[g/m³]	165,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	10,8	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
<b>Wandabstände</b>	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		46,8	50,7	50,2	47,7		
Messwerte	[m/s]	10,8	11,2	11,2	10,9		
Achse 2, [Pa]		51,6	52,9	51,6	50,9		
Messwerte	[m/s]	11,3	11,5	11,3	11,2		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	50,3		U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade	
mittlere Gasgeschwindigkeit	[m/s]	11,2		± 0,3	2,6 %	4	
Volumenstrom, Betriebszustand	[m³/h]	61.839		± 1.719	2,8 %	7	
Volumenstrom, Normzustand, feucht	[m³/h]	39.769		± 1.096	2,8 %	9	
Volumenstrom, Normzustand, trocken	[m³/h]	32.996		± 1.083	3,3 %	23	
Volumenstrom im Bezugzustand	[m³/h]	42.037		Bezugs-Sauerstoffgehalt:		11,0	


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Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	18.03.2017 /12:35		Sachverständiger: Wilhelm Vortherms (TÜV NORD)				
Luftdruck	[mbar]	997,0	u= 0,4	Absolutdruck Kanal	[mbar]	966,0	
Differenzdruck Kanal/Umgebung	[mbar]	-31,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,8056	
Abgastemperatur	[°C]	133,0	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2565	
Sauerstoffgehalt	[Vol.-%]	8,0	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3494	
Kohlendioxidgehalt	[Vol.-%]	11,0	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,0	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,3	
Gasfeuchte	[g/m³]	165,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,8	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,0	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:	2		Messpunkte je Achse:			4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		55,9	57,6	60,2	58,6		
Messwerte	[m/s]	11,8	12,0	12,2	12,1		
Achse 2, [Pa]		56,9	59,4	60,5	56,8		
Messwerte	[m/s]	11,9	12,1	12,3	11,9		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	58,2	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	12,0	± 0,3	2,4 %	4		
Volumenstrom, Betriebszustand	[m³/h]	66.633	± 1.726	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	42.723	± 1.128	2,6 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	35.447	± 1.130	3,2 %	25		
Volumenstrom im Bezugszustand	[m³/h]	46.223	Bezugs-Sauerstoffgehalt:		11,0		

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Bestimmung des Abgasvolumenstroms nach VDI-Richtlinie 2640, Blatt 3						 Version 7.10, 08.01.2013	
Betreiber:	Forus Energigjenvinning						
Anlage:	Linie 2						
Messquerschnitt:	Abgaskanal						
Betriebszustand:	I = Regelbetrieb						
Bemerkungen:	keine						
Datum/Uhrzeit	18.03.2017 /14:15			Sachverständiger:		Wilhelm Vortherms (TÜV NORD)	
Luftdruck	[mbar]	998,0	u= 0,4	Absolutdruck Kanal	[mbar]	966,0	
Differenzdruck Kanal/Umgebung	[mbar]	-32,0	u= 0,0	Dichte Betriebszustand	[kg/m³]	0,7995	
Abgastemperatur	[°C]	135,6	u= 1,3	Dichte Normzustand, feucht	[kg/m³]	1,2550	
Sauerstoffgehalt	[Vol.-%]	8,5	u= 0,13	Dichte Normzustand, trocken	[kg/m³]	1,3476	
Kohlendioxidgehalt	[Vol.-%]	10,6	u= 0,25	Wasserdampfgehalt	[Vol.-%]	17,0	
Schwefeldioxidgehalt	[g/m³]	0,1	u= 0,00	max. lokale Geschwindigkeit	[m/s]	12,3	
Gasfeuchte	[g/m³]	165,0	u= 4,7	min. lokale Geschwindigkeit	[m/s]	11,7	
Staurohrfaktor	□	1,00		Verhältnis max/min		1,1	
Durchmesser	[m]	1,400	u= 0,0050				
Strömungsquerschnitt	[m²]	1,539	u= 0,011				
Anzahl Messachsen:		2		Messpunkte je Achse:		4	
Wandabstände	[m]	0,09	0,35	1,05	1,31		
Achse 1, [Pa]		56,0	56,6	58,7	57,4		
Messwerte	[m/s]	11,8	11,9	12,1	12,0		
Achse 2, [Pa]		54,7	58,5	60,9	56,5		
Messwerte	[m/s]	11,7	12,1	12,3	11,9		
Achse 3, [Pa]							
Messwerte	[m/s]						
Achse 4, [Pa]							
Messwerte	[m/s]						
<b>Ergebnisse mit Angabe der erweiterten Messunsicherheit nach VDI 4219</b>							
mittlerer Staudruck	[Pa]	57,4	U (0,95) absolut	U (0,95) relativ	eff. Freiheitsgrade		
mittlere Gasgeschwindigkeit	[m/s]	12,0	± 0,3	2,4 %	4		
Volumenstrom, Betriebszustand	[m³/h]	66.411	± 1.723	2,6 %	8		
Volumenstrom, Normzustand, feucht	[m³/h]	42.310	± 1.119	2,6 %	9		
Volumenstrom, Normzustand, trocken	[m³/h]	35.104	± 1.120	3,2 %	25		
Volumenstrom im Bezugzustand	[m³/h]	43.845	Bezugs-Sauerstoffgehalt:		11,0		

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Isokinetische Staub-Probenahme mit Gasuhr								
<b>Betreiber</b>	<b>Forus Energigjenvinning</b>							
<b>Anlage</b>	<b>Linie 2</b>							
<b>Mess-Querschnitt</b>	<b>Abgaskanal</b>							
<b>Bemerkungen</b>	<b>keine</b>							
<b>O<sub>2</sub>-Bezugswertrechnung</b>	<b>mit Gutrechnung (wenn O<sub>2</sub> &lt; Bezugs-O<sub>2</sub>)</b>							
<b>Datum / Sachverständiger</b>	<b>17.03.2017</b>							
Betriebszustand Kennzeichen		Regelbetrieb	Regelbetrieb	Regelbetrieb	Regelbetrieb			
Volumenstrom Vn [m³/h]		34757	35232	35269	35479			
Probe	Filter	5024	5025	5026	5027			
Probenahmezeit	von	9:30:00	11:15:00	13:00:00	14:45:00			
	bis	11:00:00	12:45:00	14:30:00	16:15:00			
Probenahmedauer (netto)	min	90,0	90,0	90,0	90,0			
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0			
<b>Parameter Mess-Querschnitt</b>								
gemessener Sauerstoffgehalt	Vol.-%	8,26	8,10	8,05	8,13			
Kohlendioxidgehalt	Vol.-%	10,8	11,0	11,1	11,0			
Gasfeuchte	g/m³	179,0	179,0	179,0	179,0			
Gastemperatur	°C	139,0	134,4	134,9	134,9			
Differenzdruck Kanal- Umgebung	mbar	-31,0	-31,0	-28,0	-31,0			
Luftdruck	mbar	990	991	991	992			
Wasserdampfgehalt	Vol.-%	18,2	18,2	18,2	18,2			
<b>Parameter Staubmessung</b>								
Sondendurchmesser	mm	13,0	13,0	13,0	13,0			
Gasuhr-Faktor		0,973	0,973	0,973	0,973			
Signal Staubmessgerät	mA	0,0	0,0	0,0	0,0			
Gasuhrtemperatur Mittel	°C	29,5	31,0	31,5	32,0			
Zählerstand Gasuhr	m³	5,405	4,941	5,198	5,159			
Unterdruck Gasuhr	mbar	0,0	0,0	0,0	0,0			
Luftdruck	mbar	990	991	991	992			
Staubmasse der Probe	mg	< 0,13	< 0,13	< 0,13	< 0,13			
<b>Rechenwerte</b>								
Mittlere Absauggeschwindigkeit	m/s	12,6	11,3	11,9	11,8			
Teilvolumenstrom Mess-Querschnitt	m³/h	6,027	5,421	5,682	5,648			
Teilvolumenstrom Norm, feucht	m³/h	3,780	3,442	3,615	3,586			
Teilvolumenstrom Normzustand	m³/h	3,092	2,815	2,957	2,933			
Teilvolumen Normzustand	Nm³	4,638	4,223	4,435	4,399			
Staubkonzentration Betriebszustand	mg/m³	< 0,0	< 0,0	< 0,0	< 0,0			
Staubkonzentration EM Norm, feucht	mg/m³	< 0,0	< 0,0	< 0,0	< 0,0			
Staubkonzentration EM Norm	mg/m³	< 0,0	< 0,0	< 0,0	< 0,0			
Staubkonzentration EB Bezugzustand	mg/m³	< 0,0	< 0,0	< 0,0	< 0,0			
Mittlere Staubkonzentration EM Norm	mg/m³					0,0		
Mittlere Staubkonzentration EB Bezug	mg/m³					0,0		
Emissionsmassenstrom	g/h	< 1,0	< 1,1	< 1,0	< 1,0			

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Isokinetische Teilstromprobenahme mit Gasuhr zur Quecksilberbestimmung							
<b>Betreiber</b>	<b>Forus Energigjenvinning</b>						
<b>Anlage</b>	<b>Linie 2</b>						
<b>Mess-Querschnitt</b>	<b>Abgaskanal</b>						
<b>Bemerkungen</b>	<b>keine</b>						
<b>O<sub>2</sub>-Bezugswertrechnung</b>	<b>mit Gutrechnung (wenn O<sub>2</sub> &lt; Bezugs-O<sub>2</sub>)</b>						
<b>Datum / Sachverständiger</b>	<b>18.03.2017</b>						Wilhelm Vortherms (TÜV NORD)
Betriebszustand Kennzeichen		Regelbetrieb	Regelbetrieb	Regelbetrieb	Regelbetrieb		
Volumenstrom V <sub>n</sub> [m <sup>3</sup> /h]		33157	32996	35447	35104		
Probe	Nr.	1 / 72	2 / 73	3 / 74	4 / 75		
Probenahmezeit	von	9:15:00	11:00:00	12:45:00	14:30:00		
	bis	10:45:00	12:30:00	14:15:00	16:00:00		
Probenahmedauer (netto)	min	90,0	90,0	90,0	90,0		
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0		
<b>Parameter Mess-Querschnitt</b>							
gemessener Sauerstoffgehalt	Vol.-%	8,06	8,09	8,36	8,38		
Kohlendioxidgehalt	Vol.-%	10,9	10,8	10,6	10,5		
Gasfeuchte	g/ m <sup>3</sup>	165,0	172,0	172,0	172,0		
Gastemperatur	°C	133,7	135,5	137,5	135,4		
Differenzdruck Kanal- Umgebung	mbar	-27,0	-29,0	-31,0	-32,0		
Luftdruck	mbar	994	996	997	998		
Wasserdampfgehalt	Vol.-%	17,0	17,6	17,6	17,6		
<b>Parameter Staubmessung</b>							
Sondendurchmesser	mm	13,0	13,0	13,0	13,0		
Gasuhr-Faktor		0,967	0,967	0,967	0,967		
Signal Betriebsmessgerät	mA	0,0	0,0	0,0	0,0		
Gasuhrtemperatur Mittel	°C	25,5	30,0	29,5	28,5		
Zählerstand Gasuhr	m <sup>3</sup>	5,038	4,960	5,096	5,176		
Unterdruck Gasuhr	mbar	0,0	0,0	0,0	0,0		
Luftdruck	mbar	994	996	997	998		
Zusatzvolumen gasf. Schwemetalle	Nm <sup>3</sup>	0,1487	0,1427	0,1475	0,1487		
<b>Rechenwerte</b>							
Mittlere Absauggeschwindigkeit	m/ s	11,9	11,7	12,1	12,3		
Teilvolumenstrom Mess-Querschnitt	m <sup>3</sup> / h	5,668	5,571	5,773	5,857		
Teilvolumenstrom Norm, feucht	m <sup>3</sup> / h	3,632	3,554	3,661	3,733		
Teilvolumenstrom Normzustand	m <sup>3</sup> / h	3,013	2,927	3,016	3,075		
Teilvolumen Normzustand	Nm <sup>3</sup>	4,520	4,391	4,524	4,613		
<b>Quecksilber, partikelgebunden und filtergängig gemäß Ziffer 5.2.2, TALuft 2002</b>							
<b>Quecksilber</b>							
filtergängig absolut	µg	0,011	0,018	0,029	0,028		
partikelgebunden absolut	µg	< 0,001	< 0,001	< 0,001	< 0,001		
filtergängig	µg/ m <sup>3</sup>	0,074	0,126	0,197	0,188		
partikelgebunden	µg/ m <sup>3</sup>	< 0,0002	< 0,0002	< 0,0002	< 0,0002		
Emissionsmassenstrom	g/ h	< 0,0025	< 0,0042	< 0,0070	< 0,0066		
Konzentration EM Norm	mg/ m <sup>3</sup>	< 0,000	< 0,000	< 0,000	< 0,000		
Konzentration EB Bezugszustand	mg/ m <sup>3</sup>	< 0,000	< 0,000	< 0,000	< 0,000		



# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Isokinetische Schwermetall-Probenahme (13./17. BImSchV) mit Gasuhr							
<b>Betreiber</b>	Forus Energigjenvinning						
<b>Anlage</b>	Linie 2						
<b>Mess-Querschnitt</b>	Abgaskanal						
<b>Bemerkungen</b>	keine						
<b>O<sub>2</sub>-Bezugswertrechnung</b>	mit Gutrechnung (wenn O <sub>2</sub> < Bezugs-O <sub>2</sub> )						
<b>Datum / Sachverständiger</b>	18.03.2017						Wilhelm Vortherms (TÜV NORD)
Betriebszustand Kennzeichen		Regelbetrieb	Regelbetrieb	Regelbetrieb	Regelbetrieb		
Volumenstrom Vn [m³/h]		33.157	32.996	35.447	35.104		
Probe	Filter	1 / 110	2 / 111	3 / 112	4 / 113		
Probenahmezeit	von	9:15:00	11:00:00	12:45:00	14:30:00		
	bis	10:45:00	12:30:00	14:15:00	16:00:00		
Probenahmedauer (netto)	min	90,0	90,0	90,0	90,0		
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0		
<b>Parameter Mess-Querschnitt</b>							
gemessener Sauerstoffgehalt	Vol.-%	8,06	8,09	8,36	8,38		
Kohlendioxidgehalt	Vol.-%	10,9	10,8	10,6	10,5		
Kohlenmonoxidgehalt	mg/ m³	2	2	2	2		
Gasfeuchte	g/ m³	172,0	172,0	172,0	172,0		
Gastemperatur	°C	133,7	135,5	137,5	135,4		
Differenzdruck Kanal- Umgebung	mbar	-27,0	-29,0	-31,0	-32,0		
Luftdruck	mbar	994	996	997	998		
Wasserdampfgehalt	Vol.-%	17,6	17,6	17,6	17,6		
<b>Parameter Staubmessung</b>							
Sondendurchmesser	mm	9,0	9,0	9,0	9,0		
Gasuhr-Faktor		0,973	0,973	0,973	0,973		
Signal Staubmessgerät	mA	0,0	0,0	0,0	0,0		
Gasuhrtemperatur Ende	°C	26,0	28,0	28,0	29,0		
Zählerstand Gasuhr	m³	2,608	2,668	2,548	2,693		
Unterdruck Gasuhr	mbar	0,0	0,0	0,0	0,0		
Luftdruck	mbar	994	996	997	998		
<b>Rechenwerte</b>							
Mittlere Absauggeschwindigkeit	m/s	12,5	12,8	12,3	12,9		
Teilvolumenstrom Mess-Querschnitt	m³/h	2,871	2,936	2,824	2,962		
Teilvolumenstrom Norm, feucht	m³/h	1,840	1,873	1,791	1,888		
Teilvolumenstrom Normzustand	m³/h	1,515	1,543	1,475	1,555		
Teilvolumen Normzustand	Nm³	2,273	2,315	2,213	2,333		

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Stoffe nach Absatz a) und c), §5, (1), 3) 17.BImSchV bzw. §§ 3 u. 4, (1), 3), 13.BImSchV							
Betreiber	Forus Energigjenvinning						
Anlage	Linie 2						
Messquerschnitt	Abgaskanal						
Probe (s. Staubprobenahmeprotokoll)	Filter	1/ 110	2/ 111	3/ 112	4/ 113	0	0
<b>Cadmium</b>							
filtergängig absolut	µg	< 0,009	< 0,015	< 0,015	< 0,014		
partikelgebunden absolut	µg	< 0,006	< 0,006	< 0,006	< 0,006		
filtergängig	µg/m³	< 0,004	< 0,006	< 0,007	< 0,006		
partikelgebunden	µg/m³	< 0,003	< 0,003	< 0,003	< 0,003		
Emissionsmassenstrom	g/h	0,0001	0,0001	0,0002	0,0002		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugzustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Thallium</b>							
filtergängig absolut	µg	< 0,05	< 0,07	< 0,08	< 0,07		
partikelgebunden absolut	µg	< 0,03	< 0,03	< 0,03	< 0,03		
filtergängig	µg/m³	< 0,022	< 0,030	< 0,036	< 0,030		
partikelgebunden	µg/m³	< 0,013	< 0,013	< 0,014	< 0,013		
Emissionsmassenstrom	g/h	0,0006	0,0007	0,0009	0,0008		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugzustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Benzo(a)pyren</b>							
	g/h	< 0,0033	< 0,0033	< 0,0035	< 0,0035		
Konzentration EM Norm	mg/m³	< 0,0001	< 0,0001	< 0,0001	< 0,0001		
Konzentration EB Bezugzustand	mg/m³	< 0,0001	< 0,0001	< 0,0001	< 0,0001		
<b>Summenbildung nach 3), Abs. a) bis c), Einzelwerte kleiner Nachweisgrenze werden als halbe Nachweisgrenze berücksichtigt</b>							
Emissionsmassenstrom, Summe Absatz a)	g/h	0,0007	0,0009	0,0010	0,0009		
Konzentration EM Norm, Summe Absatz a)	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugzustand, Summe Absatz a)	mg/m³	0,000	0,000	0,000	0,000		
Emissionsmassenstrom, Summe Absatz c), unten	g/h	0,0139	0,0179	0,0126	0,0120		
Konzentration EM Norm, Summe Absatz c), unten	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezug, Summe Absatz c), unten	mg/m³	0,000	0,000	0,000	0,000		

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Stoffe nach Absatz b), §§ (1), 3) 17. BImSchV bzw. §§ 3 u. 4, (1), 3), 13. BImSchV							
Betreiber	Forus Energiegewinnung						
Anlage	Linie 2						
Messquerschnitt	Abgaskanal						
Probe (s. Staubprobenahmeprotokoll)	Filter	1/ 110	2/ 111	3/ 112	4/ 113	0,000	0,000
<b>Antimon [Abs. b)]</b>							
filtergängig absolut	µg	< 0,19	< 0,29	< 0,30	< 0,28		
partikelgebunden absolut	µg	< 0,12	0,61	< 0,12	< 0,12		
filtergängig	µg/m³	< 0,08	< 0,13	< 0,14	< 0,12		
partikelgebunden	µg/m³	< 0,05	0,26	< 0,05	< 0,05		
Emissionsmassenstrom	g/h	0,0023	0,0108	0,0034	0,0030		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Arsen [Abs. b)]</b>							
filtergängig absolut	µg	< 0,16	< 0,24	< 0,25	< 0,23		
partikelgebunden absolut	µg	< 0,10	0,12	< 0,10	< 0,10		
filtergängig	µg/m³	< 0,07	< 0,10	< 0,11	< 0,10		
partikelgebunden	µg/m³	< 0,04	0,05	< 0,05	< 0,04		
Emissionsmassenstrom	g/h	0,0019	0,0034	0,0028	0,0025		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Blei [Abs. b)]</b>							
filtergängig absolut	µg	5,06	0,26	0,31	0,39		
partikelgebunden absolut	µg	0,35	1,10	0,28	0,16		
filtergängig	µg/m³	2,23	0,11	0,14	0,17		
partikelgebunden	µg/m³	0,15	0,48	0,13	0,07		
Emissionsmassenstrom	g/h	0,0789	0,0194	0,0095	0,0083		
Konzentration EM Norm	mg/m³	0,002	0,001	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,002	0,000	0,000	0,000		
<b>Chrom [Abs. b)]</b>							
filtergängig absolut	µg	0,18	0,31	0,31	0,28		
partikelgebunden absolut	µg	< 0,04	0,36	0,08	< 0,04		
filtergängig	µg/m³	0,08	0,13	0,14	0,12		
partikelgebunden	µg/m³	< 0,02	0,16	0,04	< 0,02		
Emissionsmassenstrom	g/h	0,0029	0,0096	0,0062	0,0045		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Cobalt [Abs. b)]</b>							
filtergängig absolut	µg	0,47	< 0,15	< 0,14	< 0,12		
partikelgebunden absolut	µg	< 0,06	< 0,06	< 0,06	< 0,06		
filtergängig	µg/m³	0,21	< 0,06	< 0,06	< 0,05		
partikelgebunden	µg/m³	< 0,03	< 0,03	< 0,03	< 0,03		
Emissionsmassenstrom	g/h	0,0073	0,0015	0,0016	0,0014		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Kupfer [Abs. b)]</b>							
filtergängig absolut	µg	0,46	3,90	0,64	0,99		
partikelgebunden absolut	µg	< 0,07	0,18	0,32	< 0,07		
filtergängig	µg/m³	0,20	1,69	0,29	0,42		
partikelgebunden	µg/m³	< 0,03	0,08	0,14	< 0,03		
Emissionsmassenstrom	g/h	0,0072	0,0582	0,0154	0,0154		
Konzentration EM Norm	mg/m³	0,000	0,002	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,001	0,000	0,000		
<b>Mangan [Abs. b)]</b>							
filtergängig absolut	µg	0,33	1,39	4,57	1,36		
partikelgebunden absolut	µg	0,04	0,24	0,01	< 0,01		
filtergängig	µg/m³	0,15	0,60	2,07	0,58		
partikelgebunden	µg/m³	0,02	0,10	0,00	< 0,00		
Emissionsmassenstrom	g/h	0,0054	0,0232	0,0734	0,0205		
Konzentration EM Norm	mg/m³	0,000	0,001	0,002	0,001		
Konzentration EB Bezugszustand	mg/m³	0,000	0,001	0,002	0,000		
<b>Nickel [Abs. b)]</b>							
filtergängig absolut	µg	< 0,11	< 0,17	< 0,18	< 0,16		
partikelgebunden absolut	µg	0,42	0,48	0,39	0,36		
filtergängig	µg/m³	< 0,05	< 0,07	< 0,08	< 0,07		
partikelgebunden	µg/m³	0,18	0,21	0,18	0,15		
Emissionsmassenstrom	g/h	0,0069	0,0081	0,0077	0,0066		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Vanadium [Abs. b)]</b>							
filtergängig absolut	µg	0,22	0,34	0,33	0,30		
partikelgebunden absolut	µg	< 0,09	< 0,09	< 0,09	< 0,09		
filtergängig	µg/m³	0,10	0,15	0,15	0,13		
partikelgebunden	µg/m³	< 0,04	< 0,04	< 0,04	< 0,04		
Emissionsmassenstrom	g/h	0,0039	0,0055	0,0060	0,0052		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Zinn [Abs. b)]</b>							
filtergängig absolut	µg	0,25	0,31	0,33	0,30		
partikelgebunden absolut	µg	< 0,11	0,43	< 0,11	< 0,11		
filtergängig	µg/m³	0,11	0,13	0,15	0,13		
partikelgebunden	µg/m³	< 0,05	0,19	< 0,05	< 0,05		
Emissionsmassenstrom	g/h	0,0044	0,0105	0,0062	0,0053		
Konzentration EM Norm	mg/m³	0,000	0,000	0,000	0,000		
Konzentration EB Bezugszustand	mg/m³	0,000	0,000	0,000	0,000		
<b>Summenbildung nach 3), Abs. b), Werte kleiner Nachweisgrenze werden als halbe Nachweisgrenze berücksichtigt</b>							
Emissionsmassenstrom, Summe Absatz b)	g/h	0,111	0,501	0,1321	0,0727		
Konzentration EM Norm, Summe Absatz b)	mg/m³	0,004	0,005	0,004	0,002		
Konzentration EB Bezugszustand, Summe Absatz b)	mg/m³	0,003	0,004	0,003	0,002		


# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

<b>Parameter</b>	<b>Fluorwasserstoff (HF)</b>					 Version 7.06 / 20.01.2014
<b>Betreiber</b>	Forus Energigjenvinning					
<b>Anlage</b>	Linie 2					
<b>Mess-Querschnitt</b>	Abgaskanal					
<b>Betriebszustand</b>	I = Regelbetrieb					
<b>Bemerkungen</b>	keine					
<b>O<sub>2</sub>-Bezugswertrechnung</b>	ja (mit Gutrechnung, Mittelwerte ohne zeitliche Wichtung)					Feldblindwert (FBW)
<b>Sachverständiger</b>	Wilhelm Vortherms (TÜV NORD)					
<b>Probenahmeparameter</b>	Nr.	HF 1	HF 2	HF 3	HF 4	BW 1
Probenahmedatum		17.03.17	17.03.17	17.03.17	17.03.17	17.03.17
Probenahme Anfang	von	9:30	11:15	13:00	14:45	Konz. ≤ FBW werden mit dem FBW weiterberechnet und gekennzeichnet.
Probenahme Ende	bis	11:00	12:45	14:30	16:15	
Probenahmedauer (netto)	hh:mm	1:30	1:30	1:30	1:30	
Betriebszustand Kennzeichen		I	I	I	I	Probenahmeparameter
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0	4,0
Emissionsbegrenzung (ELV)	mg/m <sup>3</sup>	4	4	4	4	
Abgas-Volumenstrom V <sub>n</sub>	m <sup>3</sup> /h	34.757	35.232	35.269	35.479	35.184
erweiterte Unsicherheit V <sub>n</sub>	% rel.	3,2	3,2	3,2	3,2	
eff. Freiheitsgrade	ny eff.	27	28	28	27	
Sauerstoffkonzentration	Vol.-%	8,3	8,1	8,1	8,1	
Sauerstoff-Messunsicherheit	± Vol.-%	0,31	0,31	0,31	0,31	
Expertenschätzung: messquerschnitt-spezifische	± % rel.					
Luftdruck	hPa	990	991	991	991	0,086
Abs.lsg.-Volumen incl. Verdünnung	l	0,105	0,106	0,100	0,106	
Gasuhr-Faktor		0,974	0,974	0,974	0,974	
Gasuhrtemperatur Anfang	°C	25,0	25,0	24,0	23,0	
Gasuhrtemperatur Ende	°C	27,0	28,0	27,0	26,0	
Unterdruck Gasuhr Anfang	hPa	0	0	0	0	
Unterdruck Gasuhr Ende	hPa	0	0	0	0	
Probevolumen Gasuhr V (p,t)	l	183,0	192,0	183,0	182,0	
Laboregebnis (Analyt)	mg	≤ 0,021000 0,00000 ≤ EG	≤ 0,021200 0,00000 ≤ EG	≤ 0,020000 0,00000 ≤ EG	≤ 0,021200 0,00000 ≤ EG	≤ 0,01720
<b>Rechenwerte</b>		(EG: laboranalytische Erfassungsgrenze, FBW: Feldblindwert)				max. Probe-Vol. bei min. Absorpt.-Vol.
Probevolumen (V <sub>n</sub> )	m <sup>3</sup>	0,1590	0,1667	0,1594	0,1591	0,1594
Konzentration, Normzustand (EM)	mg/m <sup>3</sup>	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1	
Konzentration, Bezugszustand (EB)	mg/m <sup>3</sup>	≤ 0,1	≤ 0,1	≤ 0,1	≤ 0,1	
Emissionsmassenstrom	kg/h	≤ 0,005	≤ 0,004	≤ 0,004	≤ 0,005	
Prüfkommentar		≤ EG	≤ EG	≤ EG	≤ EG	FBW ≤ EG
maximale Konzentration (EM)	mg/m <sup>3</sup>	≤ ± 0,056	0,13			
mittlere Konzentration (EM)	mg/m <sup>3</sup>	≤	0,13			≤ 0,108
maximale Konzentration (EB)	mg/m <sup>3</sup>	≤ ± 0,043	0,10			
mittlere Konzentration (EB)	mg/m <sup>3</sup>	≤	0,10			≤
maximaler Massenstrom	kg/h	≤ ± 0,002	0,005			
mittlerer Massenstrom	kg/h	≤	0,005			
<b>Erweiterte Messunsicherheiten, Kombination direkter/indirekter Ansatz, VDI 4219 u. QSV 00420)</b>						
Unsicherheit, Konzentration EM	± mg/m <sup>3</sup>	0,055	0,054	0,054	0,056	Feldblindwert ≤ 10 % ELV
	± % rel.	41,9	42,4	43,0	41,9	
	± % ELV	1,38	1,35	1,35	1,39	
Rechenmethode		indirekt	indirekt	indirekt	indirekt	
Unsicherheit, Konzentration EB	± mg/m <sup>3</sup>	0,04	0,04	0,04	0,04	
	± % rel.	41,9	42,0	42,5	41,9	
	± % ELV	1,09	1,03	1,03	1,09	
Unsicherheit, Massenstrom	± kg/h	0,0019	0,0019	0,0019	0,0020	
	± % rel.	42,0	42,0	42,0	42,0	

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG


<b>Parameter</b>	<b>Chlorwasserstoff (HCl)</b>					 Version 7.06 / 20.01.2014
<b>Betreiber</b>	Forus Energigjenvinning					
<b>Anlage</b>	Linie 2					
<b>Mess-Querschnitt</b>	Abgaskanal					
<b>Betriebszustand</b>	I = Regelbetrieb					
<b>Bemerkungen</b>	keine					
<b>O<sub>2</sub>-Bezugswertrechnung</b>	ja (mit Gutrechnung, Mittelwerte ohne zeitliche Wichtung)					
<b>Sachverständiger</b>	Wilhelm Vortherms (TÜV NORD)					Feldblindwert (FBW)
<b>Probenahmeparameter</b>	Nr.	HCL 1	HCL 2	HCL 3	HCL 4	BW 1
Probenahmedatum		18.03.17	18.03.17	18.03.17	18.03.17	18.03.17
Probenahme Anfang	von	9:15	11:00	12:45	14:30	Konz. ≤ FBW werden mit dem FBW weiterberechnet und gekennzeichnet.
Probenahme Ende	bis	10:45	12:30	14:15	16:00	
Probenahmedauer (netto)	hh:mm	1:30	1:30	1:30	1:30	
Betriebszustand Kennzeichen		I	I	I	I	
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0	Probenahmeparameter
Emissionsbegrenzung (ELV)	mg/m <sup>3</sup>	60	60	60	60	60,0
Abgas-Volumenstrom Vn	m <sup>3</sup> /h	33.157	32.996	35.447	35.104	34.176
erweiterte Unsicherheit Vn	% rel.	3,3	3,3	3,2	3,2	
eff. Freiheitsgrade	ny eff.	23	23	25	25	
Sauerstoffkonzentration	Vol.-%	8,1	8,1	8,4	8,4	
Sauerstoff-Messunsicherheit	± Vol.-%	0,12	0,12	0,12	0,12	
Expertenschätzung: messquerschnitt-spezifische	± % rel.					
Luftdruck	hPa	990,0	992,0	993,0	994,0	
Abs.lsg.-Volumen incl. Verdünnung	l	0,120	0,131	0,134	0,114	0,093
Gasuhr-Faktor		0,994	0,994	0,994	0,994	
Gasuhrtemperatur Anfang	°C	24,1	25,2	25,3	25,3	
Gasuhrtemperatur Ende	°C	26,4	25,3	25,5	25,4	
Unterdruck Gasuhr Anfang	hPa	0	0	0	0	
Unterdruck Gasuhr Ende	hPa	0	0	0	0	
Probevolumen Gasuhr V (p,t)	l	182,0	185,0	182,0	185,0	
Laborergebnis (Analyt)	mg	0,163000 0,00000	0,226000 0,00000	0,279000 0,00000	0,191000 0,00000	≤ 0,00430
<b>Rechenwerte</b>		(EG: laboranalytische Erfassungsgrenze, FBW: Feldblindwert)				max. Probe-Vol. bei min. Absorpt.-Vol.
Probevolumen (Vn)	m <sup>3</sup>	0,1618	0,1648	0,1622	0,1651	0,1651
Konzentration, Normzustand (EM)	mg/m <sup>3</sup>	1,0	1,4	1,7	1,2	FBW ≤ EG
Konzentration, Bezugszustand (EB)	mg/m <sup>3</sup>	0,8	1,1	1,4	0,9	
Emissionsmassenstrom	kg/h	0,033	0,045	0,061	0,041	
maximale Konzentration (EM)	mg/m <sup>3</sup>	± 0,211	1,7			
mittlere Konzentration (EM)	mg/m <sup>3</sup>		1,31			≤ 0,026
maximale Konzentration (EB)	mg/m <sup>3</sup>	0,2	1,4			
mittlere Konzentration (EB)	mg/m <sup>3</sup>		1,0			≤
maximaler Massenstrom	kg/h	± 0,008	0,061			
mittlerer Massenstrom	kg/h		0,045			
<b>Erweiterte Messunsicherheiten, Kombination direkter/indirekter Ansatz, VDI 4219 u. QSV 00420</b>						
Unsicherheit, Konzentration EM	± mg/m <sup>3</sup>	0,13	0,17	0,21	0,15	Feldblindwert ≤ 10 % ELV
	± % rel.	12,8	12,5	12,3	12,5	
	± % ELV	0,21	0,29	0,35	0,24	
Rechenmethode		indirekt	indirekt	indirekt	indirekt	
Unsicherheit, Konzentration EB	± mg/m <sup>3</sup>	0,100	0,133	0,167	0,115	
	± % rel.	12,8	12,6	12,3	12,6	
	± % ELV	0,17	0,22	0,28	0,19	
Unsicherheit, Massenstrom	± kg/h	0,0043	0,0058	0,0076	0,0052	
	± % rel.	13,0	12,8	12,5	12,8	

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

# TÜV NORD Umweltschutz


Environmental monitoring body registered in accordance with § 29 BImSchG

<b>Parameter</b>	<b>Ammoniak</b>					
<b>Betreiber</b>	Forus Energigjenvinning					
<b>Anlage</b>	Linie 2					
<b>Mess-Querschnitt</b>	Abgaskanal					
<b>Betriebszustand</b>	I = Regelbetrieb					
<b>Bemerkungen</b>	keine					
<b>O<sub>2</sub>-Bezugswertrechnung</b>	ja (mit Gutrechnung, Mittelwerte ohne zeitliche Wichtung)					Version 7.06 / 20.01.2014
<b>Sachverständiger</b>	Wilhelm Vortherms (TÜV NORD)					Feldblindwert (FBW)
<b>Probenahmeparameter</b>	Nr.	NH3 1	NH3 2	NH3 3	NH3 4	BW 1
Probenahmedatum		17.03.17	17.03.17	17.03.17	17.03.17	17.03.17
Probenahme Anfang	von	9:30	11:15	13:00	14:45	Konz. ≤ FBW werden mit dem FBW weiterberechnet und gekennzeichnet.
Probenahme Ende	bis	11:00	12:45	14:30	16:15	
Probenahmedauer (netto)	hh:mm	1:30	1:30	1:30	1:30	
Betriebszustand Kennzeichen		I	I	I	I	
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0	Probenahmeparameter
Emissionsbegrenzung (ELV)	mg/m <sup>3</sup>	10	10	10	10	10,0
Abgas-Volumenstrom V <sub>n</sub>	m <sup>3</sup> /h	34.757	35.232	35.269	35.479	35.184
erweiterte Unsicherheit V <sub>n</sub>	% rel.	3,2	3,2	3,2	3,2	
eff. Freiheitsgrade	ny eff.	27	28	28	27	
Sauerstoffkonzentration	Vol.-%	8,3	8,1	8,1	8,1	
Sauerstoff-Messunsicherheit	± Vol.-%	0,31	0,31	0,31	0,31	
Expertenschätzung: messquerschnitt-spezifische	± % rel.					
Luftdruck	hPa	990,0	991,0	991,0	991,0	
Abs.lsg.-Volumen incl. Verdünnung	l	0,116	0,120	0,120	0,124	0,094
Gasuhr-Faktor		0,994	0,994	0,994	0,994	
Gasuhrtemperatur Anfang	°C	25,9	26,0	26,0	26,0	
Gasuhrtemperatur Ende	°C	26,5	26,0	26,8	27,0	
Unterdruck Gasuhr Anfang	hPa	0	0	0	0	
Unterdruck Gasuhr Ende	hPa	0	0	0	0	
Probevolumen Gasuhr V (p,t)	l	183,0	181,0	184,0	185,0	
Laborergebnis (Analyt)	mg	0,230000 0,00000	0,034000 0,00000	0,029000 0,00000	0,040000 0,00000	≤ 0,00470
<b>Rechenwerte</b>		(EG: laboranalytische Erfassungsgrenze, FBW: Feldblindwert)				max. Probe-Vol. bei min. Absorpt.-Vol.
Probevolumen (V <sub>n</sub> )	m <sup>3</sup>	0,1622	0,1607	0,1631	0,1639	0,1622
Konzentration, Normzustand (EM)	mg/m <sup>3</sup>	1,4	0,2	0,2	0,2	
Konzentration, Bezugszustand (EB)	mg/m <sup>3</sup>	1,1	0,2	0,1	0,2	
Emissionsmassenstrom	kg/h	0,049	0,007	0,006	0,009	FBW ≤ EG
maximale Konzentration (EM)	mg/m <sup>3</sup>	0,1	1,4			
mittlere Konzentration (EM)	mg/m <sup>3</sup>		0,5			≤ 0,029
maximale Konzentration (EB)	mg/m <sup>3</sup>	0,1	1,1			
mittlere Konzentration (EB)	mg/m <sup>3</sup>		0,4			≤
maximaler Massenstrom	kg/h	± 0,005	0,049			
mittlerer Massenstrom	kg/h		0,018			
<b>Erweiterte Messunsicherheiten, Kombination direkter/indirekter Ansatz, VDI 4219 u. QSV 00420)</b>						
Unsicherheit, Konzentration EM	± mg/m <sup>3</sup>	0,137	0,028	0,026	0,030	Feldblindwert ≤ 10 % ELV
	± % rel.	9,66	13,1	14,5	12,2	
	± % ELV	1,37	0,28	0,26	0,30	
Rechenmethode		indirekt	indirekt	indirekt	indirekt	
Unsicherheit, Konzentration EB	± mg/m <sup>3</sup>	0,1	0,0	0,0	0,0	
	± % rel.	9,86	13,2	14,5	12,3	
	± % ELV	1,10	0,22	0,20	0,23	
Unsicherheit, Massenstrom	± kg/h	0,0049	0,0010	0,0009	0,0011	
	± % rel.	10,0	13,3	14,7	12,4	



# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

<b>Parameter</b>	<b>Schwefeloxide (als Schwefeldioxid)</b>					 Version 7.06 / 20.01.2014
<b>Betreiber</b>	Forus Energigjenvinning					
<b>Anlage</b>	Linie 2					
<b>Mess-Querschnitt</b>	Abgaskanal					
<b>Betriebszustand</b>	I = Regelbetrieb					
<b>Bemerkungen</b>	keine					
<b>O<sub>2</sub>-Bezugswertrechnung</b>	ja (mit Gutrechnung, Mittelwerte ohne zeitliche Wichtung)					
<b>Sachverständiger</b>	Wilhelm Vortherms (TÜV NORD)					
<b>Probennahmeparameter</b>	Nr.	1/2	3/4	5/6	7/8	BW 1
Probenahmedatum		17.03.17	17.03.17	17.03.17	17.03.17	17.03.17
Probenahme Anfang	von	9:30	11:15	13:00	14:45	Konz. ≤ FBW werden mit dem FBW weiterberechnet und gekennzeichnet.
Probenahme Ende	bis	11:00	12:45	14:30	16:15	
Probenahmedauer (netto)	hh:mm	1:30	1:30	1:30	1:30	
Betriebszustand Kennzeichen		I	I	I	I	
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0	11,0	200,0
Emissionsbegrenzung (ELV)	mg/m <sup>3</sup>	200	200	200	200	
zulässige erw. Messunsicherheit	± % ELV	20	20	20	20	
Abgas-Volumenstrom V <sub>n</sub>	m <sup>3</sup> /h	34.757	35.232,000	35.269	35.479	35.184
erw. eiterete Unsicherheit V <sub>n</sub>	% rel.	3,2	3,2	3,2	3,2	
eff. Freiheitsgrade	ny eff.	27	28	28	27	
Sauerstoffkonzentration	Vol.-%	8,3	8,1	8,1	8,1	
Sauerstoff-Messunsicherheit	± Vol.-%	0,31	0,31	0,31	0,31	
Expertenschätzung: messquerschnitt-spezifische	± % rel.					
Luftdruck	hPa	990,0	991,0	991,0	991,0	
Abs.lsg.-Volumen incl. Verdünnung	l	0,121	0,595	0,585	0,615	0,093
Gasuhr-Faktor		0,927	0,927	0,927	0,927	
Gasuhrtemperatur Anfang	°C	24,0	31,0	31,0	32,0	
Gasuhrtemperatur Ende	°C	33,0	34,0	34,0	35,0	
Unterdruck Gasuhr Anfang	hPa	0	0	0	0	
Unterdruck Gasuhr Ende	hPa	0	0	0	0	
Probevolumen Gasuhr V (p,t)	l	184,0	182,0	182,0	182,0	
Laborergebnis (Analyt)	mg	3,88000 0,00000	6,53000 0,00000	6,98000 0,00000	7,41000 0,00000	≤ 0,00410
<b>Rechenwerte</b>		(EG: laboranalytische Erfassungsgrenze, FBW: Feldblindwert)				max. Probe-Vol. bei min. Absorpt.-Vol.
Probevolumen (V <sub>n</sub> )	m <sup>3</sup>	0,1509	0,1475	0,1475	0,1470	0,1509
Konzentration, Normzustand (EM)	mg/m <sup>3</sup>	25,7	44,3	47,3	50,4	FBW ≤ EG
Konzentration, Bezugszustand (EB)	mg/m <sup>3</sup>	20,2	34,3	36,6	39,2	
Emissionsmassenstrom	kg/h	0,894	1,560	1,669	1,789	
maximale Konzentration (EM)	mg/m <sup>3</sup>	± 4,53	50,4			
mittlere Konzentration (EM)	mg/m <sup>3</sup>		41,9			
maximale Konzentration (EB)	mg/m <sup>3</sup>	± 3,61	39,2			≤
mittlere Konzentration (EB)	mg/m <sup>3</sup>		32,6			
maximaler Massenstrom	kg/h	± 0,170	1,789			
mittlerer Massenstrom	kg/h		1,478			
<b>Erweiterte Messunsicherheiten, Kombination direkter/indirekter Ansatz, VDI 4219 u. QSV 00420)</b>						
Unsicherheit, Konzentration EM	± mg/m <sup>3</sup>	4,53	4,53	4,53	4,53	Feldblindwert ≤ 10 % ELV
	± % rel.	17,6	10,2	9,57	8,99	
	± % ELV	2,27	2,27	2,27	2,27	
zulässige Unsicherheit eingehalten		ja	ja	ja	ja	
Rechenmethode		direkt	direkt	direkt	direkt	
Unsicherheit, Konzentration EB	± mg/m <sup>3</sup>	3,6	3,6	3,6	3,6	
	± % rel.	17,7	10,4	9,79	9,23	
	± % ELV	1,79	1,79	1,79	1,81	
Unsicherheit, Massenstrom	± kg/h	0,1597	0,1664	0,1675	0,1695	
	± % rel.	17,9	10,7	10,0	9,48	

# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

PCDD/F+PCB-Bestimmung - Probegasvolumen und Isokinetik				
<b>Betreiber</b>	<b>Forus Energigjenvinning</b>			
<b>Anlage</b>	<b>Linie 2</b>			
<b>Mess-Querschnitt</b>	<b>Abgaskanal</b>			
<b>Bemerkungen</b>	<b>keine</b>			
<b>O<sub>2</sub>-Bezugswertrechnung</b>	<b>mit Gutrechnung (wenn O<sub>2</sub> &lt; Bezugs-O<sub>2</sub>)</b>			
<b>Sachverständiger</b>	Wilhelm Vortherms (TÜV NORD)			
Betriebszustand Kennzeichen		Normal	Normal	Normal
Volumenstrom V <sub>n</sub> [m <sup>3</sup> /h]		36.375	34.757	33.157
Probenbezeichnung		F2.1	F2.2	F2.3
Datum		16.03.2017	17.03.2017	18.03.2017
Probenahmezeit	von	10:15	9:30	9:15
	bis	16:15	15:30	15:15
Probenahmedauer (netto)	min	360	360	360
Bezugssauerstoffgehalt	Vol.-%	11,0	11,0	11,0
<b>Parameter Mess-Querschnitt</b>				
gemessener Sauerstoffgehalt	Vol.-%	8,3	8,1	8,2
Kohlendioxidgehalt	Vol.-%	10,5	11,0	10,7
Kohlenmonoxidgehalt	mg/m <sup>3</sup>	4	6	2
Gasfeuchte	g/m <sup>3</sup>	172,0	179,0	165,0
Gastemperatur	°C	130,1	136,0	135,2
Differenzdruck Kanal- Umgebung	mbar	-32,00	-31,00	-27,00
Luftdruck	mbar	1.000	990	994
Wasserdampfgehalt	Vol.-%	17,6	18,2	17,0
<b>Parameter Staubmessung</b>				
Sondendurchmesser	mm	9	9	9
Gasuhr-Faktor		0,976	0,976	0,976
Gasuhrtemperatur Mittel	°C	26,5	27,5	27,0
Zählerstand Gasuhr	m <sup>3</sup>	11,210	10,001	10,567
Unterdruck Gasuhr	mbar	0,0	0,0	0,0
Luftdruck	mbar	999	989	993
<b>Rechenwerte</b>				
Mittlere Absauggeschwindigkeit	m/s	13,4	12,2	12,6
Teilvolumenstrom Mess-Querschnitt	m <sup>3</sup> /h	3,074	2,792	2,894
Teilvolumenstrom Norm, feucht	m <sup>3</sup> /h	1,990	1,764	1,848
Teilvolumenstrom Normzustand	m <sup>3</sup> /h	1,639	1,443	1,533
Teilvolumen Normzustand	Nm <sup>3</sup>	9,833	8,656	9,198

# TÜV NORD Umweltschutz

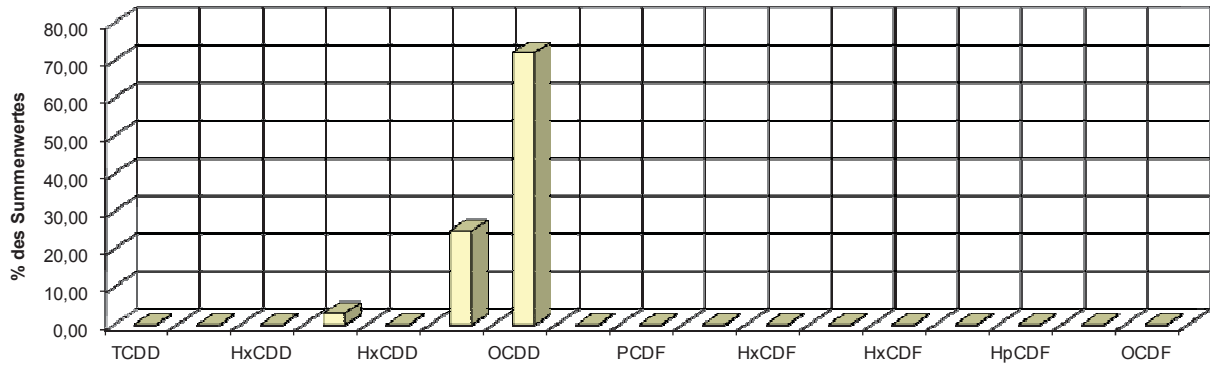
Environmental monitoring body registered in accordance with § 29 BImSchG

<b>Bestimmung der Emission von Dioxinen und Furanen</b>					
<b>Betreiber</b>		Forus Energigjenvinning			
<b>Anlage</b>		Linie 2			
<b>Mess-Querschnitt</b>		Abgaskanal			
<b>Bemerkungen</b>					
<b>O<sub>2</sub>-Bezugswertrechnung</b>		mit Gutrechnung (wenn O <sub>2</sub> < Bezugs-O <sub>2</sub> )			
<b>Sachverständiger</b>		Wilhelm Vortherms (TÜV NORD)			
Betriebszustand Kennzeichen		Normal	Normal	Normal	<b>FBW</b>
Volumenstrom Vn	[m³/h]	36.375	34.757	33.157	36.375
Probenbezeichnung		F2.1	F2.2	F2.3	BW
Datum		16.03.2017	17.03.17	18.03.17	16.03.17
Probenahmezeit	von	10:15	9:30	9:15	
	bis	16:15	15:30	15:15	
Bezugssauerstoffgehalt	[Vol.-%]	11	11	11	11
gemessener Sauerstoffgehalt	[Vol.-%]	8,3	8,1	8,2	8,2
Probenvolumen (Vn)	dm³	9.833	8.656	9.198	9.833
<b>Analytmengen</b>					
2,3,7,8-TetraCDD	[pg]	< 2	< 2	< 2	< 2
1,2,3,7,8-PentaCDD	[pg]	< 4	< 4	< 4	< 4
1,2,3,4,7,8-HexaCDD	[pg]	< 6	< 6	< 6	< 6
1,2,3,6,7,8-HexaCDD	[pg]	6,03	< 6	< 6	< 6
1,2,3,7,8,9-HexaCDD	[pg]	< 6	< 6	< 6	< 6
1,2,3,4,6,7,8-HeptaCDD	[pg]	49,3	43,5	35,9	< 30
OctaCDD	[pg]	143	< 100	< 100	< 100
Summe TetraCDD	[pg]	38,7	29,5	32,1	12,8
Summe PentaCDD	[pg]	38,3	36,8	28,1	< 40
Summe HexaCDD	[pg]	75,8	65,0	60,8	< 60
Summe HeptaCDD	[pg]	95,1	77,3	68,6	< 60
2,3,7,8-TetraCDF	[pg]	< 4	< 4	< 4	< 4
1,2,3,7,8-PentaCDF	[pg]	< 4	< 4	< 4	< 4
2,3,4,7,8-PentaCDF	[pg]	< 4	< 4	< 4	< 4
1,2,3,4,7,8-HexaCDF	[pg]	< 6	< 6	< 6	< 6
1,2,3,6,7,8-HexaCDF	[pg]	< 6	< 6	< 6	< 6
2,3,4,6,7,8-HexaCDF	[pg]	< 6	< 6	< 6	< 6
1,2,3,7,8,9-HexaCDF	[pg]	< 6	< 6	< 6	< 6
1,2,3,4,6,7,8-HeptaCDF	[pg]	< 30	< 30	< 30	< 30
1,2,3,4,7,8,9-HeptaCDF	[pg]	< 30	< 30	< 30	< 30
OctaCDF	[pg]	< 100	< 100	< 100	< 100
Summe TetraCDF	[pg]	41,2	32,1	44,0	29,5
Summe PentaCDF	[pg]	35,4	22,7	31,6	25,6
Summe HexaCDF	[pg]	32,2	< 60	< 60	31,2
Summe HeptaCDF	[pg]	< 120	< 120	< 120	< 120
Summe PCDD (Tetra-Octa)	[pg]	391	209	190	-
Summe PCDF (Tetra-Octa)	[pg]	109	54,8	75,6	-
Summe PCDD+PCDF (Tetra-Octa)	[pg]	499	263	265	-
TE nach DIN EN 1948-3 Nr. 12 a)	[pg]	< 13,09	< 13,02	< 12,94	< 12,88
TE nach 17.BImSchV / LAI	[pg]	1,14	0,44	0,36	
<b>Emissionen [TE nach 17. BImSchV; WHO 2005]</b>					
Emissionskonzentration E <sub>M</sub>	[ng/m³]	0,000	0,000	0,000	< 0,00131
Emissionskonzentration E <sub>B</sub>	[ng/m³]	0,000	0,000	0,000	< 0,00131
Massenstrom	[µg/h]	0,004	0,002	0,001	< 0,048
Analytmenge Benzo(a)pyren	[µg]	< 1	< 1	< 1	< 1
<b>Emissionen Benzo(a)pyren</b>					
Emissionskonzentration E <sub>M</sub>	[mg/m³]	< 0,00010	< 0,00012	< 0,00011	< 0,00010
Emissionskonzentration E <sub>B</sub>	[mg/m³]	< 0,00010	< 0,00012	< 0,00011	< 0,00010
Massenstrom	[g/h]	< 0,004	< 0,004	< 0,004	< 0,0037

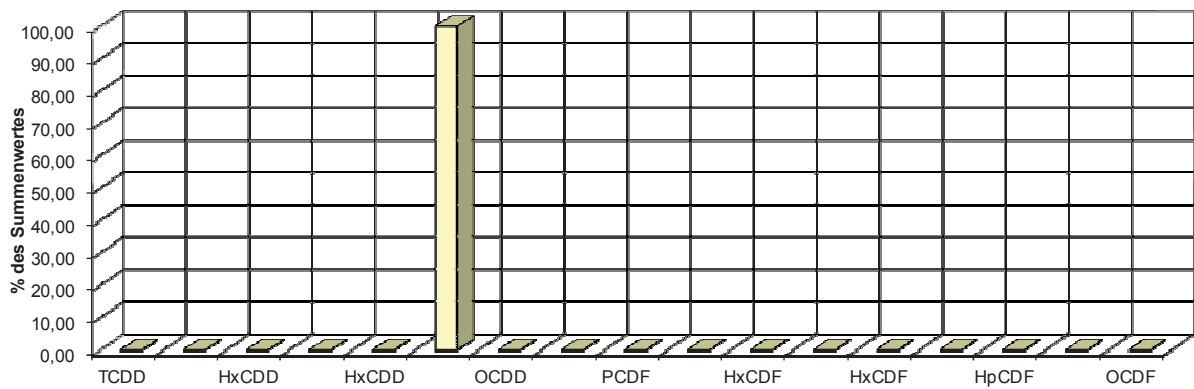
# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

## Forus Energigjenvinning, Linie 2 Anteile der Einzelkongenere PCDD/F Emissionsmessungen am 16.03.2017



## Forus Energigjenvinning, Linie 2 Anteile der Einzelkongenere PCDD/F Emissionsmessungen am 17.03.2017



# TÜV NORD Umweltschutz

Environmental monitoring body registered in accordance with § 29 BImSchG

Forus Energigjenvinning, Linie 2

Anteile der Einzelkongenere PCDD/F

Emissionsmessungen am 18.03.2017

