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TÜV ®

Fröling
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Your reference:	**Your message from:**	**Our reference:**	**Date:**
Order no. 27257	12/08/2008	08-UW/Wels-EX-285/1 SD/SD	28/12/2008

Subject: Emission measurements in the acceptance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel

Testing laboratory, supervisory board, certification centre, calibration board, initial test and boiler test centre

R E P O R T

from the accredited testing laboratory and supervisory board

on the inspections carried out on 07/10/2008, 08/10/2008 and 20/10/2008

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Testing laboratory:	**TÜV AUSTRIA SERVICES GMBH** **Division Environmental Protection** Am Thalbach 15 A-4600 Thalheim/Wels
Test report no.:	08-UW/Wels-EX-285/1
Test report date:	28/12/2008

Report on execution of emission measurements in the acceptance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel

Client:	Fröling Heizkessel- und Behälterbau GesmbH, Industriestraße 12, A-4710 Grieskirchen
Operator:	Fröling Heizkessel- und Behälterbau GesmbH, Industriestraße 12, A-4710 Grieskirchen
Location:	Fröling Heizkessel- und Behälterbau GesmbH, Dr. Ernst Hutterer Straße 1, Stritzing industrial park, KG Tolleterau, A-4710 St. Georgen bei Grieskirchen
Type of measurement:	Emission measurements in the acceptance test at a biomass heating system
Order no.:	Order no. 27257
Order date:	12/08/2008
Date of measurement:	07/10/2008, 08/10/2008 and 20/10/2008
Contents:	27 pages

Task:	Taking emission measurements in the acceptance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel.

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1. TASK DEFINITION

1.1 CLIENT

Fröling Heizkessel- und Behälterbau GesmbH, Industriestraße 12, A-4710 Grieskirchen.

Contact: Mr. Hable
Telephone number: 0043-(0)7248-606-0

1.2 OPERATOR

Fröling Heizkessel- und Behälterbau GesmbH, Industriestraße 12, A-4710 Grieskirchen.

1.3 LOCATION

Fröling Heizkessel- und Behälterbau GesmbH, Dr. Ernst Hutterer Straße 1, Stritzing industrial park, KG Tolleterau, A-4710 St. Georgen bei Grieskirchen.

1.4 UNIT

The subject system is a Lambdamat 1000 biomass heating system, manufactured by Fröling Heizkessel- und Behälterbau GesmbH, with a nominal heat output of 1000 kW.

The useful heat of the biomass heating system is used for room heating and water heating in the production plant of Fröling Heizkessel- und Behälterbau GesmbH installed at the Stritzing industrial park.

The unit was granted official approval under Grieskirchen District Commission notification, no. Ge20-82-2006 of 22/09/2006.
A subsidy contract for this system was also signed with Kommunalkredit Public Consulting GmbH, application number A6.12272.

1.5 DATE OF MEASUREMENTS

Date of measurements:	07/10/2008 and 08/10/2008 (Acceptance test in nominal and partial load) 20/10/2008: Safety devices test
Date of the next individual measurements:	2013 (5-year interval according to notification conditions (lit. 1))

In accordance with the FAV (regulation concerning heating systems), repeated tests should be carried out on the system yearly as per § 25 FAV.

1.6 CAUSE OF MEASUREMENTS

Taking emission measurements in the acceptance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel.

1.7 TASK

Taking emission measurements in the acceptance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel.

The tests should be carried out using the fuel wood chips, according to the design of the plant, at nominal heat output and at a maximum of 30 % of the heat output range of the biomass heating system (minimum heat output, below-mentioned “partial load”).

6 measurement values for the pollutants listed in point 1.8 should be determined at every load point, as consecutive average values for half-hour periods.

The emission measurements are used to determine the exhaust gas loss and the boiler efficiency (calculation by using the indirect method) at the observed operating conditions.

As per order, the safety devices installed on the system - temperature controller, safety temperature limiter (STL) and the devices for dissipating excess heat – should also be checked in accordance with the specifications of ÖNORM EN 303-5.

1.7.1 Emission limit values

The emission limit values used at the time the report was written, for evaluation of emission behaviour and exhaust gas loss of this system are listed below (limit values as per notification conditions (lit.1, Grieskirchen District Commission notification, no. Ge20-82-2006 of 22/09/2006), FAV (BGBl. II No. 331/1997) and in accordance with technical conditions of the subsidy contract with Kommunalkredit Public Consulting GmbH, application number A6.12272 (lit.2)).

Parameter	Limit value in accordance with notification (lit.1) and FAV *	Limit value in accordance with subsidy contract (lit. 2)
Dust	150 mg/m³	100 mg/m³
Carbon monoxide (CO)	250 mg/m³	250 mg/m³
Nitrogen oxides (NOx, given as NO_2)	250 mg/m³	250 mg/m³
Organic carbon substances (organ. C, given as carbon)	20 mg/m³	20 mg/m³
Exhaust gas loss at nominal heat output	≤ 19 %	≤ 17 %

* … Limit values in accordance with FAV valid for commercial installations

In accordance with the FAV and the subsidy contract, at least three measurement values should be determined for emission measurements for the parameters dust, CO, NOx and C. These measurement values should be calculated as half-hour averages within a period of three hours for each parameter, at nominal heat output and in the partial load range.

The given emission limit values for substance concentrations refer to a dry flue gas basis at 13 % O2 by volume, and at 0°C and 1013 hPa.
The emission limit values have been met in accordance with FAV if none of the half-hour averages (minus the margin of error of the measuring procedure) exceeds the limit value.
The limit value for exhaust gas loss at nominal heat output is the arithmetic mean value over the entire test duration at operating condition nominal heat output.

1.8 COMPONENTS TO BE MEASURED

- Dust
- Carbon monoxide (CO)
- Nitrogen oxides (NO and NO_2 given as NO2)
- Unburnt gaseous organic carbon substances (C)
- Radiation loss
- Exhaust gas loss (calculation in accordance with FAV)
- Boiler efficiency (calculation using indirect method)

1.9 COORDINATION

Coordination regarding date, measuring scope and procedure took place with Mr. Hable from the client in the run-up of the measurements.

1.10 LIST OF ALL PERSONS WHO LOCALLY TOOK PART AT SAMPLING

On the part of TÜV AUSTRIA: Mr. Schrögendorfer
On the part of the client: Mr. Hable, Mr. Mayr

1.11 PARTICIPATION OF FURTHER INSTITUTES

None, all tasks were performed by TÜV AUSTRIA SERVICES GMBH.

1.12 TECHNICALLY RESPONSIBLE PERSONS

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e: mai@tuv.at
Mr. Schrögendorfer Eng. t: 0043-(0)7242/61383 direct dial 8215
e: sd@tuv.at

1.13 BASES

1.13.1 Standards in the accredited area of the testing laboratory

- Accreditation decree of the TÜV AUSTRIA SERVICES GMBH, issued by the Austrian Minister of Economics and Labour, no. 92.714/0365-I/12/2007 from 20/08/2007.

- ÖNORM M 5861-1 - "Manual determination of particle concentrations in fluid gases; Gravimetric Method, General requirements"; 01/04/1993.

- ÖNORM M 9415 "Measuring technique; Measurement of the emission of substances into the atmosphere", 01/01/2004 (historical document).

- ÖNORM EN 303-5 - "Heating boilers – Part 5: Heating boilers for solid fuels, hand and automatically stocked, nominal heat output of up to 300 kW – Terminology, requirements, testing and marking"; 01/07/1999. (Accredited scope of the testing laboratory limited to activities in accordance to point 5, no limitation of the accredited scope of the inspection body).

- ÖNORM EN 14789 - " Stationary source emissions - Determination of volume concentration of oxygen (O2) - Reference method: Paramagnetism"; 01/04/2006.

- ÖNORM EN 14792 - " Stationary source emissions - Determination of mass concentration of nitrogen oxides (NOx) - Reference method: Chemiluminescence"; 01/04/2006.

- ÖNORM EN 15058 - " Stationary source emissions - Determination of the mass concentration of carbon monoxide (CO) - Reference method: Non-dispersive infrared spectrometry"; 01/08/2006.

- ÖNORM EN 12619 - " Stationary source emissions - Determination of the mass concentration of total gaseous organic carbon at low concentrations in flue gases - Continuous flame ionisation detector method“; 01/09/1999.

- VDI 2066, Part 1 - " Particulate matter measurement - Dust measurement in flowing gases - Gravimetric determination of dust load”; 01/11/2006.

- VDI/VDE 2640, Part 3, "Measurement of gas flow in circular, annular or rectangular sections of conduits velocity area method"; Nov. 1983.

1.13.2 Other relevant bases

- Quality assurance manual of TÜV AUSTRIA SERVICES GMBH.
- BGBl. II No. 331/1997 – "331st Federal Law Gazette of the Minister of Economic Matters on construction, mode of operation, equipment and permitted emission level systems of units firing solid, liquid and gaseous fuels in commercial plants (regulation concerning heating systems – FAV), 18/11/1999.
- Grieskirchen District Commission notification, no. Ge20-82-2006 of 22/09/2006; lit. 1.
- Subsidy contract with Kommunalkredit Public Consulting GmbH, application number A6.12272; lit.2.
- OÖ LGBl. 56/1995 – "Agreement according to article 15 a B-VG about "Schutzmaßnahmen betreffend Kleinfeuerungen"", 18/07/1995.
- BGBl. 388/1995 – "388. BGBl. " Agreement between the Austrian Federation and the Austrian Federal States according to article 15a B-VG about "Einsparung von Energie"; 09/06/1995.
- ÖNORM EN 304 - " Heating boilers - Test code for heating boilers for atomizing oil burners"; 1992/A1:1998.
- ÖNORM CEN/TS 14774-1, prestandard - " Solid biofuels - Methods for determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method", 01/11/2004.
- DIN 43710 - " Measurement and control; electrical temperature sensors, reference tables and materials of thermocouples"; September 1977 (historical document).
- DIN 4702, part 2 - " Central heating boilers; test code"; March 1990.
- DIN 1942 - " Acceptance test code for steam generators"; February 1994 (historical document).

2. DESCRIPTION OF THE UNIT, INPUT MATERIALS

2.1 KIND OF UNIT

The subject system is a Lambdamat 1000 biomass heating system, manufactured by Fröling Heizkessel- und Behälterbau GesmbH, with a nominal heat output of 1000 kW.

The useful heat of the biomass heating system is used for room heating and water heating in the production plant of Fröling Heizkessel- und Behälterbau GesmbH installed at the Stritzing industrial park.

2.2 TECHNICAL DATA OF THE UNIT (AS ON BOILER PLATE OR AS OPERATOR INFORMATION

2.2.1 Boiler

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Type:	Lambdamat 1000
Serial no.:	1000.0032.R10
Year of construction:	2007
Nominal heat output:	1000 kW
Maximum allowable operating temperature:	95°C
Maximum allowable temperature:	110°C
Maximum allowable operating pressure:	4 bar
Water content:	2390 l
Boiler class:	3
Additional equipment:	Heat exchanger, integrated in the boiler, periodic cleaning of the heat exchanger using compressed air pulses
Ash removal:	subsurface ash removal

2.2.2 Firing

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Type:	FUR 1000 KO Lambdamat
Grate:	reciprocating grate
Serial no.:	1000.0028.R.07
Nominal heat output:	750 – 980 kW
for wood with water content of 20 %:	980 kW
for wood with water content of 40 %:	890 kW

2.2.3 Combustion air fan

Manufacturer:	Gebhardt
Type:	TEM01-0250-4D-11 RD
Device no.:	250-158806-949675/1
Year of construction:	2006
Power:	0.75 kW
Speed (rpm):	1395 min^{-1}

The combustion air is brought into an air jacket with the combustion air fan and distributed from there into the following zones via air flaps:

Primary zone:	Air used below the grate
Secondary zone:	Air used above the grate
Tertiary zone:	Air used in the area of the middle vault

2.2.4 Input materials as per authorisation notification

- Biomass in the form of chipped wood

2.3 TYPICAL MODE OF OPERATION OF SYSTEM AS SPECIFIED BY OPERATOR

Chipped wood were used, the fuel that the system was designed for.

The biomass heating system is currently operated according to the heat requirements at the Fröling Heizkessel- und Behälterbau GesmbH plant at the Stritzing industrial park, over the entire load range it was designed for.

2.4 DESCRIPTION OF EMISSION SOURCE

2.4.1 Emission source (as specified by operator)

Design:	stainless steel
Number of stack drafts:	1
Connected boilers:	Lambdamat 1000
Stack height above ground:	approx. 18 m
Stack height above roof:	approx. 8 m
Outlet diameter:	D = 0.59 m
Outlet sectional area:	A = 0.27 m^2

2.4.2 Country-specific allocation

Province:	Upper Austria
Responsible authority:	Grieskirchen District Commission

2.5 APPLIANCES FOR COLLECTION AND REDUCTION OF EMISSIONS

Exhaust fan (appliance for emission collection)

Manufacturer:	Scheuch
Type:	vmk50 0400 hb14, model gl360
Serial no.:	V0004/07
Volume flow:	10000 m^3/h
Required output:	4.06/7.23 kW
Speed (rpm):	1476 min^{-1}

Exhaust gas recirculation (AGR, appliance for emission reduction)

Reduced pollutants:	NOx
Manufacturer:	Klima Celje
Type:	105CVX280/4a
Year of construction:	2005
Volume flow:	0.97 m^3/s
Speed (rpm):	2880 min^{-1}
Motor output:	2.2 kW

Multi cyclone (appliance for emission reduction)

Reduced pollutants:	Dust
Manufacturer:	Scheuch
Type:	Multi cyclone 230, mk 230-04/03

3. DESCRIPTION OF THE SAMPLING POINTS

3.1 POSITION OF THE MEASUREMENT CROSS SECTIONS

The measurements took place at the following measuring points:

Gaseous flue gas components and flue gas temperature after the flue gas exit of the boiler
The measuring point was situated in the horizontal flue gas pipe directly after the flue gas exit of the boiler.

Dust and flue gas volume flow
The partial flue gas flows were taken from the chimney of the unit.

Length of the straight inlet:	approx. 5	m	(IL)
Length of the straight outlet:	> 3	m	(OL)
Circular cross section:	D = 0.59 m		
Measurement cross section:	A = 0.27 m^2		

3.2 NUMBER OF MEASUREMENT AXES AND POSITION OF MEASUREMENT POINTS IN THE MEASUREMENT CROSS SECTION

The samples are taken at the measurement point after the flue gas exit of the boiler at one measurement point in the measurement cross section (in the centre of the duct).
The flue gas volume flow measurements were taken at the measuring point chimney in 2 measurement axes and the dust measurements were taken at the measuring point chimney in 1 measurement axis.
2 measurement points were observed for each measurement axis, and the position of the measurement points was determined as area centroids of ring segments of equal area.

4. MEASUREMENT AND ANALYSIS METHODA, APPARATUS

4.1 DETERMINATION OF THE FLUE GAS BOUNDARY CONDITIONS

4.1.1 Flue gas velocity

Measurement method:	Determining differential pressure between dynamic pressure and static pressure in the flue gas pipe
Directives:	VDI 2066, page 1 and VDI/VDE 2640, page 3
Measurement sensor:	Prandt'l Pitot tube
Instrument:	Calibrated micro manometer
Manufacturer:	Special Instruments
Type:	Digima FP auto zero
Measurement range:	0 – 5 hPa
Measurement uncertainty:	± 5 % of the measured value

4.1.2 Static pressure in the flue gas pipe (draught)

Measuring Method:	Determination of differential pressure between static pressure in the flue gas pipe and ambient pressure
Directives:	VDI 2066, part 1
Measurement sensor:	Prandt'l Pitot tube
Instrument:	calibrated micro manometer, data see point 4.1.1

4.1.3 Air pressure at the height of the sampling point

Instrument:	Calibrated precision barometer for the measurement of absolute air pressure
Manufacturer:	Lufft
Type:	Model 2039, transportable
Measurement uncertainty:	± 1 hPa

4.1.4 Flue gas temperature

Measurement method:	Thermoelectric
Directives:	DIN 43710
Measurement sensor:	Thermoelements Fe-Cu-Ni
Instrument:	Digital display instrument
Manufacturer:	Mesa Electronic
Type:	A009.411.40.40
Measurement uncertainty:	Range ≤ 150°C: ± 2°C
	Range > 150°C: ± 1.5 % of the measured value

4.1.5 Ambient air and combustion air temperature, temperature at dust measurement gas meter

Instrument:	Portable electronic measuring instrument
Measurement sensor:	Pt 100
Manufacturer:	Testo
Type:	Testo 925
Measurement uncertainty:	± 1°C

4.1.6 Proportion of water vapour in the flue gas (flue gas humidity)

Measurement method:	Two-thermometer-method (Psychrometer)
Instrument:	Psychrometer
Measurement uncertainty:	± 10 % of the measured value

4.1.7 Flue gas density

The flue gas density was calculated taking into account the flue gas proportions of O_2, CO_2, N_2, CO, flue gas humidity, flue gas temperature and the pressure conditions in the duct.

4.1.8 Flue gas volume flow

Calculated using the values from 4.1.1 to 4.1.4 and 4.1.6 to 4.1.7.

4.2 GASEOUS AND VAPOUROUS EMISSIONS

4.2.1 Continuously recording measuring instruments

O2	Manufacturer:	Servomex
	Type:	OA570
	Measurement method:	Paramagnetism
	Measurement range:	0-25 % of vol.
	Measurement uncertainty:	± 0.4 % of vol.
CO	Manufacturer:	Siemens
	Type:	Ultramat 22P
	Measurement method:	Non-dispersive infrared spectroscopy
	Measurement range:	0-1000 ppm
	Measurement uncertainty:	Range up to 100 ppm: ± 4 ppm
		Range 100-1000 ppm: ± 4 % of measurement value

CO_2	Manufacturer:	Siemens
	Type:	Ultramat 22P
	Measurement method:	Non-dispersive infrared spectroscopy
	Measurement range:	0-20 % of vol.
	Measurement uncertainty:	± 0.4 % of vol.
NOx	Manufacturer:	ECO Physics
	Type:	CLD 822S
	Measurement method:	Chemiluminescence
	Measurement range used:	0-200 ppm
	Measurement uncertainty:	± 2 % of range performance
C		
	Manufacturer:	Testa
	Type:	FID 123
	Measurement method:	Flame ionisation
	Measurement range used:	0-100 ppm C3H8
	Measurement uncertainty/ measurement:	± 1.5 % of range performance

4.2.1.1 Measurement location design

The measurement location design for the determination of the continuously recorded gaseous flue gas components is described below.

Sampling probe:	Material/heating:	Stainless steel, heated by flue gas
	Length:	0.5 m
	Internal diameter:	6 mm
	External diameter:	8 mm
Filter:	Manufacturer:	M & C
	Type:	PSP 4000 H/C
	Heating:	Heated to 180°C
	Pore size:	2 µm (ceramic)

Sampling line 1 before gas conditioning:

	Manufacturer:	Winkler
	Material/heating:	Teflon, heated on 160°C
	Length:	5 m
	Internal diameter:	4 mm
	External diameter:	6 mm

Downstream the sampling line 1, directly upstream of the gas conditioning, the sample gas was divided into the downstream test gas lines using a metal T-piece:

- Sampling line 2: for determining the concentration of C
- Sampling line 3: for determining the concentrations of O2, CO, CO_2 and NOx

Sampling line 2 (upstream of flame ionisation analyzer):

Manufacturer:	JCT
Material/heating:	Teflon, heated to 160°C
Length:	5 m
Internal diameter:	6 mm
External diameter:	8 mm

Sampling line 3 (upstream of gas conditioning):

Material/heating:	silicone, unheated
Length:	0.05 m
Internal diameter:	6 mm
External diameter:	8 mm

Gas conditioning: Combined suction, filter, cooling and controlling unit

Manufacturer:	M & C
Type:	PSS 10-1
Cooler material:	glass
Cooler temperature:	approx. 4°C
Condensate removal:	automatic

Sampling line 4 downstream of gas conditioning:

Material/heating:	Teflon, unheated
Length:	25 m
Internal diameter:	4 mm
External diameter:	6 mm

4.2.1.2 Recording of the measured values

Logging software:	Dasylab software, Dewetron
Module:	ISM 100 Intelligent sensor module V.2.O., Gantner
Scanning rate:	1 second
Resolution of analogue-digital converter:	16 bit
Measurement uncertainty:	± 0.3 % of the measured value

4.2.1.3 Adjustment of the measurement instruments

Before the start of measurements and after the end, the reference points of the gas analysis instruments were adjusted by feeding the test gases listed below from Messer Austria.

Parameter	Test gas concentration in accordance with analysis certificate	Manufacturer	Analysis tolerance of the test gas in accordance with analysis certificate
CO	590 ppm CO	Messer Austria	± 2 % of test gas concentration
CO_2	15.06 % CO_2 by volume	Messer Austria	± 2 % of test gas concentration
NOx	69.3 ppm NO	Messer Austria	± 2 % of test gas concentration
C	90.9 ppm propane	Messer Austria	± 2 % of test gas concentration

The reference point of the O_2-analyzer was adjusted with oxygen from the ambient air.
The zero points of the gas analysis instruments were adjusted with nitrogen of quality 5.0.

4.2.1.4 Checking the instrument characteristic

The characteristic of the gas analysis instruments employed are checked once a year in accordance with the quality assurance manual from TÜV AUSTRIA SERVICES GMBH.
Descriptions are available at the test centre in Thalheim/Wels for reference.

4.2.1.5 Response time of the entire measuring apparatus

The response time (t90 time) for all continuously recorded flue gas component measurements was less than 120 seconds and was determined by measuring the time required from when the probe was inserted into the flue gas duct until 90 % of the final value was reached.

4.3 PARTICULATE EMISSIONS

4.3.1 Dust

Sampling probe:	titanium, heated by flue gas
Position of the filter holder:	internal duct
Particle filter:	plane filter made of quartz fibre
Quartz flat filter: Manufacturer:	Munktell Filter AB, Sweden
Type:	MK 360
Extraction capacity:	99.998 % related to 0.3 µm in accordance to DOP-test
Temperature stability:	max. 950°C work temperature
Material:	maximum pure silicia-fibre
Characteristics:	not hydrophobic, no organic bonding agents
Differential pressure:	180 Pa at 3 cm/s exhaust velocity
Transfer of the samples:	the time period between sampling and weighing of the used dust filters amounted to less than a week
Measurement uncertainty:	± 5 % of the measured value, ± 0.74 mg/m³ at minimum
Sampling and analysis:	in accordance to ÖNORM M 5861-1
Drying temperature of the collection medium	
before exposure:	180 °C
after exposure:	160 °C
Drying time of the collection medium (equilibration)	
before and after exposure:	approx. 12 hours
Gas volume meter:	
Manufacturer:	Elster
Type:	dry design, BK G2,5
Measurement uncertainty volume:	± 2 % of the measured value
Analytical balance:	
Manufacturer:	Mettler
Type:	AE 163
Weighing range:	0 – 31 g
Resolution:	0.01 mg

The oxygen concentration at the measuring point chimney (dust and flue gas volume measuring point) was determined with an OA 570 oxygen measuring instrument from Servomex, after drying the sample gas on silica gel (see point 4.2.1).

The leakage test of the apparatus for dust measurement took place via applying a vacuum before carrying out the individual measurements

4.4 WATER CONTENT OF THE FUEL

On the day of the measurements the expert from TÜV AUSTRIA SERVICES GMBH (Mr .Schrögendorfer) extracted a sample of the fuel fired during the measurement period.
The specifications of the test fuel are shown under point 5 of the test report.

The water content of the fuel was determined by drying in a drying chamber as per ÖNORM CEN/TS 14774-1, prestandard, part 1, in the Wels test centre of TÜV AUSTRIA SERVICES GMBH.

4.5 EXHAUST GAS LOSS

The exhaust gas loss was calculated in accordance with the 331st regulation of the Austrian Ministry for Economic Affairs on construction, mode of operation, equipment and permitted emission level of systems for combustion of solid, liquid or gaseous fuels in commercial plants (regulation concerning heating systems - FAV) of 18/11/1997 using the following formula:

Exhaust gas loss (%) $q_A = (tA - tL) . [A2/(21 - O2) + B]$

tA..... flue gas temperature in °C
tL..... combustion air temperature in °C
O2..... dry oxygen content of the flue gases in % of vol.
A2..... 0.6975 for biomass with a fuel water content of 27.8 %
B..... 0.0144 for biomass with a fuel water content of 27.8 %

The input data used for calculating the exhaust gas loss is listed under point 6.2.1 in the report.

4.6 BOILER EFFICIENCY

The boiler efficiency was not determined using the direct method as per ÖNORM EN 303-5, as it would have been disproportionately expensive to determine the quantity of fuel fed to the boiler during the test period given the fuel heat output of this biomass combustion system.

The indirect method was used to determine the boiler efficiency rating for the individual operating statuses from the averages of the flue gas, combustion air and ambient (room) temperatures, as well as the flue gas composition. The following loss values were calculated based on the calculation formalisms listed in ÖNORM EN 304, and these were used to calculate the boiler efficiency given in the test report.

- Loss through sensible heat of the products of combustion (q_A, exhaust gas loss, determination method see point 4.5)
- Loss through incomplete combustion (qb, latent heat in the flue gases)
- Loss through radiation from the boiler surfaces (qs, radiation loss)
- Loss through unburnt fuel in the ash (qr, the value of 0.3 % was used as the loss proportion for both nominal heat output and partial load operation for the boiler efficiency calculation)

4.7 SURFACE TEMPERATURES

For the determination of the mean surface temperature the boiler surface of the boiler type Lambdamat 1000 was divided in 26 incremental areas, whereby a total of 130 measuring points were regarded.

The radiation loss of the boiler was calculated from the measured surface temperatures, based on DIN 4702-2 and ÖNORM EN 304. The calculated values of radiation loss are given in point 6.2.7.

The estimated uncertainty for the specified radiation loss is ± 10 % of the given values.
The specified value of the radiation loss as a percentage is based on the useful heat output produced during the test period.

4.7.1 Surface temperature measuring instrument

Manufacturer:		Testo
Type:	Measuring instrument:	KM 330
	Sensor:	SK 21M
Measurement uncertainty:		± 1°C

5. OPERATING CONDITIONS OF THE UNIT DURING THE MEASUREMENTS

The Lambdamat 1000 biomass heating system was operated during the measurement period at nominal heat output and at a maximum of 30 % of the heat output range of the biomass heating system (minimum heat output, “partial load”).

The following test fuel was used, and this is the fuel the system was designed for.
Test fuel: Chipped wood, size G30, water content 27.8 %, with low proportions of fine-fraction and bark

The heat output ranges were set before the start of measurement by the client representatives who were present for measurements.

The heat output produced in the measurement period was determined using the following heat meters, which were installed on the biomass heating system.

Data of the heat meter installed on the system:

Heat meter:	Manufacturer:	Aquametro Messtechnik GmbH
	Type:	Calec MB
	Serial no.:	4707717/07
	Year of construction:	2007
	Installation location:	Return
	Temperature measurement:	Pt 100
Flow measuring system:		
	Manufacturer:	Siemens
	Type:	Sitrans F US Sonoflo, Sono 3000/3300 CT
	Converter:	7ME315/388404N445
	Transducer:	FDK-085L2229
	Flow:	Qn: 70 m^3/h Qmax: 84 m^3/h, Qmin: 1.4 m^3/h
	Pulse ratio:	1 pulse / l
	Location:	Return

The mode of operation of the system during the measurement period of the emission measurements is shown below.
The mode of operation was taken from the operating displays of the boiler controller and the heat meter that were installed on the system.
The data from the operating displays listed here was recorded continuously by the client with a sampling frequency set-point of 15 seconds, and the data collected was given to TÜV AUSTRIA SERVICES GMBH when the measurements were finished in the form of csv files.

	Nominal heat output	Partial load
Date of measurements:	07/10/2008	08/10/2008
Measuring time (from – to):	10:14-13:44	07:19-10:40
Heat output useful generated (kW):	1022	265
Flow (m^3/h):	33.6	13.9
Boiler temperature (°C):	84	77
Flow temperature (°C):	73	82
Return temperature (°C):	60	70
Combustion chamber temperature (°C):	905	884
Negative pressure in the combustion chamber (Pa):	30	63
Outdoor temperature (°C):	15	12
Primary air (%):	82	19
Secondary air (%):	15	0
Primary AGR (%) / Secondary AGR (%):	0 / 0	0 / 0
Tertiary air (%):	18	0
Feed (%):	99	23

6. SUMMARY AND DISCUSSION OF MEASUREMENT RESULTS

6.1 EVALUATION OF THE OPERATING CONDITIONS DURING MEASUREMENTS

The Lambdamat 1000 biomass heating system was operated during the measurement period at nominal heat output and at a maximum of 30 % of the heat output range of the biomass heating system (minimum heat output, “partial load”), using chipped wood, the fuel the system was designed to use.

There were no special occurrences during the measurement period.

This means that the operating statuses mainly seen during the measurements were the operating statuses that currently lead to characteristic emissions for the system in controlled operation.

6.2 MEASUREMENT RESULTS

All given pollutant concentrations are based on a dry flue gas basis at 0°C, 1013 hPa with actual oxygen content of the flue gases (actual O2) and calculated based on a hypothetical oxygen content of the flue gases of 13 % O_2 of the volume as an average over the measurement periods shown in the dimension mg/m³.

Measurement uncertainties are shown in the form measurement value ± estimated measurement uncertainty of the relevant measurement value for the entire procedure.
Values marked with “<“show the relative detection limit of the measurement procedure or the measuring instrument configuration used.

6.2.1 Flue gas boundary conditions

Gaseous component measuring point	Nominal heat output		Partial load	
Date of measurements:	07.10.2008		08.02.2008	
Measurement time (from – to):	10:14-13:44		07:19-10:40	
Average oxygen concentration (% of vol.):	7.9	± 0.4	11.6	± 0.4
Average carbon dioxide concentration (% of vol.):	12.4	± 0.4	9.1	± 0.4
Average combustion air temperature (°C):	22	± 2	14	± 2
Average flue gas temperature (°C):	158	± 2	97	± 2

Dust measuring point (chimney)	Nominal heat output		Partial load	
Date of measurements:	07.10.2008		08.02.2008	
Measuring time (from – to):	10:14-13:44		07:19-10:40	
Average oxygen concentration (% of vol.):	8.2	± 0.4	12.0	± 0.4
Air pressure at the height of the measuring point (hPa):	983	± 1	980	± 1
Static pressure in the flue gas duct (hPa):	- 0.12	± 0.02	- 0.07	± 0.02
Average flue gas temperature (°C):	140	± 2	80	± 2
Absolute flue gas humidity (kg/m³):	0.14	± 0.01	0.10	± 0.01
Average flue gas speed (m/s):	3.9	± 0.2	1.1	± 0.1
Average flue gas volume flow at actual O_2:*				
- Operating status (m³/h):	3800	± 380	1110	± 110
- humid (m³/h, 0°C, 1013 hPa):	2440	± 240	830	± 80
- dry (m³/h, 0°C, 1013 hPa):	2070	± 210	740	± 70

*...rounded to ± 10 m³/h

6.2.2 Dust

Boiler type Lambdamat 1000 – nominal heat output, fuel chipped wood

Date	Measuring time from - to	Dust concentration based on actual O2 mg/m³	13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
07/10/2008	10:16-10:46	55 ± 3	34 ± 2	8.0 ± 0.4
	10:53-11:23	42 ± 2	26 ± 2	8.3 ± 0.4
	11:28-11:58	45 ± 2	28 ± 2	8.3 ± 0.4
	12:04-12:34	41 ± 2	26 ± 2	8.3 ± 0.4
	12:39-13:09	44 ± 2	28 ± 2	8.2 ± 0.4
	13:14-13:44	45 ± 2	28 ± 2	8.2 ± 0.4
Average value		45 ± 2	28 ± 2	8.2 ± 0.4

Boiler type Lambdamat 1000 – partial load, fuel chipped wood

Date	Measuring time from - to	Dust concentration based on actual O2 mg/m³	13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
08/10/2008	07:19-07:49	32 ± 2	27 ± 2	11.4 ± 0.4
	07:53-08:23	37 ± 2	33 ± 2	12.0 ± 0.4
	08:27-08:57	22 ± 2	20 ± 2	12.0 ± 0.4
	09:01-09:31	26 ± 2	23 ± 2	12.0 ± 0.4
	09:35-10:05	38 ± 2	34 ± 2	12.0 ± 0.4
	10:10-10:40	24 ± 2	22 ± 2	12.4 ± 0.4
Average value		30 ± 2	27 ± 2	12.0 ± 0.4

6.2.3 Carbon monoxide (CO)

Boiler type Lambdamat 1000 – nominal heat output, fuel chipped wood

Date	Measuring time from - to	CO concentration based on actual O2 mg/m³	CO concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
07/10/2008	10:14-10:44	24 ± 5	14 ± 4	7.6 ± 0.4
	10:44-11:14	11 ± 5	7 ± 4	7.9 ± 0.4
	11:14-11:44	12 ± 5	7 ± 4	8.0 ± 0.4
	11:44-12:14	11 ± 5	7 ± 4	7.9 ± 0.4
	12:14-12:44	9 ± 5	6 ± 4	8.0 ± 0.4
	12:44-13:14	15 ± 5	9 ± 4	7.8 ± 0.4
Average value		14 ± 5	8 ± 4	7.9 ± 0.4

Boiler type Lambdamat 1000 – partial load, fuel chipped wood

Date	Measuring time from - to	CO concentration based on actual O2 mg/m³	CO concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
08/10/2008	07:19-07:49	39 ± 6	32 ± 5	11.1 ± 0.4
	07:53-08:23	41 ± 6	35 ± 5	11.6 ± 0.4
	08:27-08:57	34 ± 6	29 ± 5	11.6 ± 0.4
	09:01-09:31	55 ± 6	47 ± 5	11.6 ± 0.4
	09:35-10:05	36 ± 6	31 ± 5	11.6 ± 0.4
	10:10-10:40	47 ± 6	42 ± 5	12.0 ± 0.4
Average value		42 ± 6	36 ± 5	11.6 ± 0.4

6.2.4 Nitrogen oxides (NOx)

The total of nitrogen oxides (NOx), measured as a total of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), is calculated and stated as nitrogen dioxide (NO_2).

Boiler type Lambdamat 1000 – nominal heat output, fuel chipped wood

Date	Measuring time from - to	NOx concentration based on actual O2 mg/m³	NOx concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
07/10/2008	10:14-10:44	166 ± 10	99 ± 6	7.6 ± 0.4
	10:44-11:14	163 ± 10	100 ± 6	7.9 ± 0.4
	11:14-11:44	165 ± 10	102 ± 6	8.0 ± 0.4
	11:44-12:14	168 ± 10	103 ± 6	7.9 ± 0.4
	12:14-12:44	169 ± 10	104 ± 6	8.0 ± 0.4
	12:44-13:14	170 ± 10	103 ± 6	7.8 ± 0.4
Average value		167 ± 10	102 ± 6	7.9 ± 0.4

Boiler type Lambdamat 1000 – partial load, fuel chipped wood

Date	Measuring time from - to	NOx concentration based on actual O2 mg/m³	NOx concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
08/10/2008	07:19-07:49	114 ± 8	92 ± 7	11.1 ± 0.4
	07:53-08:23	114 ± 8	97 ± 7	11.6 ± 0.4
	08:27-08:57	115 ± 8	98 ± 7	11.6 ± 0.4
	09:01-09:31	112 ± 8	95 ± 7	11.6 ± 0.4
	09:35-10:05	113 ± 8	96 ± 7	11.6 ± 0.4
	10:10-10:40	110 ± 8	98 ± 8	12.0 ± 0.4
Average value		113 ± 8	96 ± 7	11.6 ± 0.4

6.2.5 Unburnt gaseous organic carbon compounds (C)

The unburnt gaseous organic carbon compounds (C) were determined using a flame ionisation analyzer (FID) without separating the individual substances.

The reference point of the flame ionisation analyzer was adjusted using propane.

The concentrations of unburnt gaseous organic carbon compounds are given as carbon (C) in the dimension mg/m³.

Boiler type Lambdamat 1000 – nominal heat output, fuel chipped wood

Date	Measuring time from - to	C concentration based on actual O2 mg/m³	C concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
07/10/2008	10:14-10:44	< 4	< 3	7.6 ± 0.4
	10:44-11:14	< 4	< 3	7.9 ± 0.4
	11:14-11:44	< 4	< 3	8.0 ± 0.4
	11:44-12:14	< 4	< 3	7.9 ± 0.4
	12:14-12:44	< 4	< 3	8.0 ± 0.4
	12:44-13:14	< 4	< 3	7.8 ± 0.4
Average value		< 4	< 3	7.9 ± 0.4

Boiler type Lambdamat 1000 – partial load, fuel chipped wood

Date	Measuring time from - to	C concentration based on actual O2 mg/m³	C concentration based on 13 % O2 by vol. mg/m³	actual O2 concentration % of vol.
08/10/2008	07:19-07:49	< 4	< 4	11.1 ± 0.4
	07:53-08:23	< 4	< 4	11.6 ± 0.4
	08:27-08:57	< 4	< 4	11.6 ± 0.4
	09:01-09:31	< 4	< 4	11.6 ± 0.4
	09:35-10:05	< 4	< 4	11.6 ± 0.4
	10:10-10:40	< 4	< 4	12.0 ± 0.4
Average value		< 4	< 4	11.6 ± 0.4

6.2.6 Exhaust gas loss

The exhaust gas losses of the combustion system, calculated on the basis of the formalisms listed in BGBl. II No. 331/1997 (FAV, see point 4.5) are given below.
The input data used for calculating, measured at the measurement point after flue gas exit of the boiler, are listed under 6.2.1 in the report.

Exhaust gas loss (%) $q_A = (tA - tL) . [A2/(21 - O2) + B]$

tA..... flue gas temperature in °C
tL..... combustion air temperature in °C
O2..... dry oxygen content of the flue gases in % of vol.
A2..... 0.6975 for biomass with a fuel water content of 27.8 %
B..... 0.0144 for biomass with a fuel water content of 27.8 %

Calculated exhaust gas losses

Lambdamat 1000, fuel chipped wood, nominal heat output: $q_A = 9.4\ \% \pm 0.5\ \%$
Lambdamat 1000, fuel chipped wood, partial load: $q_A = 7.4\ \% \pm 0.4\ \%$

6.2.7 Radiation loss

For the determination of the mean surface temperature the boiler surface of the boiler type Lambdamat 1000 was divided in 26 incremental areas, whereby a total of 130 measuring points were regarded.

The radiation loss of the boiler was calculated from the measured surface temperatures, based on DIN 4702-2 and ÖNORM EN 304.
The specified value of the radiation loss as a percentage is based on the useful heat output produced during the test period.

Calculated radiation losses, measurement date 07/10/2008 – 08/10/2008:

Nominal heat output, Lambdamat 1000, fuel chipped wood: $q_S = 0.30 \pm 0.06\ \%$
Partial load, Lambdamat 1000, fuel chipped wood: $q_S = 2.02 \pm 0.20\ \%$

6.2.8 Boiler efficiency

The boiler efficiency was calculated using the indirect method.
The procedure for calculating the boiler efficiency is shown under point 4.6 of the test report.

Boiler efficiency rating, boiler type - Lambdamat 1000, fuel - woodchips

Operating status	Nominal heat output	Partial load
Heat output useful generated (kW)	1022	265
Loss through sensible heat of the products of combustion (q_A, %)	9.4 ± 0.5	7.4 ± 0.4
Loss through incomplete combustion (qb, %)	< 0.1	< 0.1
Loss through radiation from the boiler surfaces (qs, %)	0.30 ± 0.06	2.02 ± 0.20
Loss through unburnt fuel in the ash (qr, %) [1)]	0.3	0.3
Boiler efficiency (calculated indirectly, %)	90.0 ± 0.6	90.3 ± 0.6

[1)] … Calculations were based on a value of 0.3 % for the loss proportion from unburnt fuel in the ash (qr) for both nominal heat output and partial load operation.

6.3 FUNCTION CHECK OF THE TEMPERATURE CONTROLLER, THE SAFETY TEMPERATURE LIMITER AND THE DEVICE FOR DISSIPATING EXCESS HEAT

The function check of the temperature controller, the safety temperature limiter and the device for dissipating excess heat of the biomass heating system was carried out in accordance with ÖNORM EN 303-5 within the framework of tests to determine the emission behaviour and the indirect boiler efficiency of the system on 20/10/2008.

The temperature sensors installed on the system by the boiler manufacturer were used to determine the flow temperatures and the boiler temperatures.

These were compared with a calibrated Pt100 temperature sensor from TÜV AUSTRIA before the test was carried out, and they were found to be working correctly.

6.3.1 Function test of the temperature controller and the safety temperature limiter installed at the boiler

Before the start of the test the water-side flow rate was fixed to the specified flow rate of nominal heat output test.
Then the firing of the unit was set to match the rated heat output of the boiler.

At the start of the test the flow temperature was a maximum of 75°C and the boiler temperature controller was set to switch the boiler off at the manufacturer's maximum set-point value of 90+3°C.

The dissipated heat output was then limited by reducing the flow to about 40 % of the nominal heat output.

The test was continued until the temperature controller was activated, and then an observation was made of the temperature at which the maximum boiler temperature was reached.

The same test was carried out again after bypassing the temperature controller.
This tested whether the safety temperature limiter switches off the heating at least at the highest value specified by the boiler manufacturer.

6.3.2 Function check on the device for dissipating excess heat

During this test the heating boiler was operated at minimal heat output and the temperature controller was put out of function.
The function of the safety temperature limiter was maintained.

Further it was guaranteed by shut-off position of the consumers that no heat output were given off to the heating system. The test was continued until the maximum boiler temperature was reached, after the device for dissipating excess heat installed in the system (emergency cooling) had activated.

6.3.3 Test results

6.3.3.1 Function check of the biomass heating system temperature controller

Settings at test start:

Water-side flow rate:	flow rate equal to the flow rate for the rated output test
Heat input:	according to nominal heat output of the heating boiler
Flow temperature:	75°C
Boiler temperature controller:	set-point value for switch off at maximum value of 90+3°C (as specified by manufacturer)
Dissipated output:	approx. 40 % of the nominal heat output
Safety temperature limiter:	response set-point value to switch off at 100°C

Test results

The temperature controller installed on the boiler worked correctly.
The operating status boiler shutdown was reached at a boiler temperature of 93°C.

The boiler temperature then rose to a maximum temperature of 94.5°C.
The safety temperature limiter and the device for dissipating excess heat did not trigger.
A temperature of 100°C at the boiler temperature sensor was also not exceeded.

The requirements of ÖNORM EN 303-5 with regard to the functioning of the temperature controller were thus fulfilled within the framework of the tests on the biomass heating system of type Lambdamat 1000.

6.3.3.2 Function check of the safety temperature limiter (STL) installed at the heating boiler

Settings at test start:

Water-side flow rate:	flow rate equal to the flow rate for the rated output test
Heat output:	according to nominal heat output of the heating boiler
Flow temperature:	75°C
Boiler temperature controller:	temperature controller deactivated
Dissipated output:	approx. 40 % of the nominal heat output
Safety temperature limiter:	response set-point value to switch off at 100°C
Device for dissipating excess heat:	deactivated

Test results

The safety temperature limiter switched off the heating of the biomass heating system at 98.5°C.
The shutdown temperature was below the value of 100°C specified by the boiler manufacturer.

The requirements of ÖNORM EN 303-5 with regard to the functioning of the safety temperature limiter were thus fulfilled within the framework of the tests on the biomass heating system of type Lambdamat 1000.

6.3.3.3 Function check on the device for dissipating excess heat

Settings at test start:

Heat input:	according to nominal heat output of the heating boiler	
Flow temperature:	75°C	
Boiler temperature controller:	temperature controller deactivated	
Dissipated output:	no heat output to the heating system	
Safety temperature limiter:	response set-point value to switch off at 100°C	
Device for dissipating excess heat:	response set-point value 100°C	
	Cold water temperature:	11°C
	Cold water pressure:	2 bar

Test results

The safety temperature limiter of the biomass heating system triggered at a boiler temperature of 98.5°C. The device for dissipating excess heat (emergency cooling) triggered at a boiler temperature of 100.5°C.

The maximum boiler temperature then rose to 110.0°C.

The requirements of ÖNORM EN 303-5 with regard to the functioning of the device for dissipating excess heat (emergency cooling) were thus satisfied within the framework of the tests on the biomass heating system of type Lambdamat 1000.

6.4 PLAUSIBILITY CHECK

The plausibility of the continuously recorded flue gas component measurements was proved by putting test gases through the measuring instruments before and after the measurements, and through a leakage check carried out before the start of measurements.

The discontinuously sampling systems were also put through a leakage check before the start of measurements.

Taking into account the measurement accuracy and measurement uncertainty of the measurement procedures used, the measuring equipment used and the mode of operation of the system during the measurement period, there are no reasons to question the plausibility of the test.

7. SUMMARY

Fröling Heizkessel- und Behälterbau GesmbH contracted TÜV AUSTRIA SERVICES GMBH to carry out emission measurements through an accordance test on the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park using chipped wood as a fuel.

The biomass heating system was operated during the measurement period at nominal heat output and at a maximum of 30 % of the heat output range of the biomass heating system (minimum heat output, “partial load”).

Within the framework of the emission measurements, the exhaust gas loss and the boiler efficiency (determined using the indirect method) were determined in the operating statuses to be observed.
6 measurement values of the pollutants listed under point 1.8 were created as consecutive half-hour averages at every load point.

As per order, the safety devices installed on the system - temperature controller, safety temperature limiter (STL) and the device for dissipating excess heat from the biomass heating system were also checked in accordance with the specifications of ÖNORM EN 303-5.
The safety devices tested in accordance with ÖNORM EN 303-5 (temperature controller, safety temperature limiter (STL) and the device for dissipating excess heat) met the requirements of ÖNORM EN 303-5 at the time of testing (see point 6.3 in the test report).

Emission limit values of the subject unit

The emission limit values used at the time the report was written, for evaluation of emission behaviour and exhaust gas loss of this system are listed below (limit values as per notification conditions (lit.1, Grieskirchen District Commission notification, no. Ge20-82-2006 of 22/09/2006), FAV (BGBl. II No. 331/1997) and in accordance with the technical conditions of the subsidy contract with Kommunalkredit Public Consulting GmbH, application number A6.12272 (lit.2)).

The given emission limit values for substance concentrations refer to a dry flue gas basis at 13 % O2 by volume, and at 0°C and 1013 hPa.

Parameter	Limit value in accordance with notification (lit.1) and FAV *	Limit value in accordance with subsidy contract (lit. 2)
Dust	150 mg/m³	100 mg/m³
Carbon monoxide (CO)	250 mg/m³	250 mg/m³
Nitrogen oxides (NOx, given as NO_2)	250 mg/m³	250 mg/m³
Organic carbon compounds (organ. C, given as carbon)	20 mg/m³	20 mg/m³
Exhaust gas loss at nominal heat output	≤ 19 %	≤ 17 %

* … Limit values in accordance with FAV valid for commercial installations

Measurement results – boiler type Lambdamat 1000, fuel chipped wood

A summary of the measurement results is shown below.

For the emission measurements, at least 6 measurement values were taken as half-hour averages for pollutant concentrations of dust, CO, NOx and C, both in the nominal heat output and in the partial load range.
The flue gas substance concentrations determined in the framework of the emission measurements refer to a dry flue gas basis at 13 % O2 by volume, and at 0°C and 1013 hPa.
The detailed measurement results are listed under point 6.2 in the test report.

Parameter	Measurement result at nominal heat output 07/10/2008	Measurement result at partial load 08/10/2008
Dust (mg/m³) [1)]	34 ± 2	34 ± 2
Carbon monoxide (CO, mg/m³) [1)]	14 ± 4	47 ± 5
Nitrogen oxides (NOx, stated as NO_2, mg/m³) [1)]	104 ± 6	98 ± 8
Organic carbon compounds (organ. C, stated as carbon, mg/m³) [1)]	< 3	< 4
Exhaust gas loss (%) [2)]	9.4 ± 0.5	7.4 ± 0.4
Boiler efficiency (determined indirectly, %) [2)]	90.0 ± 0.6	90.3 ± 0.6

[1)]...maximum half-hour average value, referred on dry flue gas basis at 0°C, 1013 hPa and 13 % O_2 by volume
[2)]...arithmetic mean value over the test period

7.1 INTERPRETATION OF MEASUREMENT RESULTS

The limit values specified in the regulators' authorisation notification were observed in the emission measurements taken on 07/10/2008 and 08/10/2008 for the Lambdamat 1000 biomass heating system installed at the Stritzing industrial park, using chipped wood as a fuel
(lit.1, Grieskirchen District Commission notification, no. Ge20-82-2006 of 22/09/2006), FAV (BGBl. II No. 331/1997) and in accordance with technical conditions of the subsidy contract with Kommunalkredit Public Consulting GmbH, application number A6.12272 (lit.2)).

The safety devices tested in accordance with ÖNORM EN 303-5 (temperature controller, safety temperature limiter and device for dissipating excess heat) met the requirements of ÖNORM EN 303-5 at the time of testing (see point 6.3 in the test report).

TÜV AUSTRIA SERVICES GMBH
Test Centre Wels
Division Environmental Protection

The authorized signatory:

TÜV AUSTRIA SERVICES GMBH TÜV AUSTRIA

G. Schrögendorfer Eng.