TRANSLATION

TÜV ÖSTERREICH

Division
Environmental
Technology and
Chemistry

Fröling Heizkessel- und Behälterbau GesmbH

Industriestraße 12
A-4710 Grieskirchen

Testing Centre Wels
A-4600
Thalheim/Wels
Am Thalbach 15
Telephone:
+43 7242 / 61 383-0
fax: direct dial 8205
eMail: wels@tuev.or.at

Contact:
Eng. G.
Schrögendorfer
Direct dial 8215
eMail: sd@tuev.or.at

Your reference:	Your message from	Our reference:	Date:
Order by phone by Mr. Hable	22.04.2005	05-UWC/Wels-EX-123/2 SD/SD	14.07.2005

Betrifft: Emission measurements at the boiler type Turbomat 500, installed at the district heating plant Grieskirchen, by firing the fuel wooden pellets

TEST REPORT

of the accredited testing laboratory and supervisory board

concerning the measurements performed on 27.04.2005

Accredited testing laboratory, supervisory board and certification centre

Notified Body 0408

Head office:
A-1015 Vienna
Krugerstraße 16
Tel.: +43 1 / 514 07-0
fax: direct dial 6005
eMail: office@tuev.or.a

Branch offices in Dornbirn, Eisenstadt, Graz, Innsbruck, Klagenfurt, Linz, Salzburg, Wels and Vienna

Affiliated companies in Athens, Budapest, Munich and Vienna

Bank connections:
CA 0066-28978/00
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Testing laboratory:	TÜV Austria Division Environmental Technology and Chemistry Am Thalbach 15 A-4600 Thalheim/Wels
Test report no.:	05-UWC/Wels-EX-123/2
Test report date:	14.07.2005

Report concerning the emission measurements at the boiler plant of the type Turbomat 500, installed at the district heating plant in Grieskirchen

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

Operating company: Peasant Bio-Energy Fröling Heizkessel- und Behälterbau GesmbH, Parz 2, A-4710 Grieskirchen.

Location: Peasant Bio-Energy Fröling Heizkessel- und Behälterbau GesmbH, district heating plant, Parz 2, plot no 161/1, KG Parz, A-4710 Grieskirchen.

Type of measurement: Emission measurements at a biomass heating plant

Order number: Order by phone by Mr. Hable

Date of order: 22.04.2005

Day of measurement: 27.04.2005

Contents: 28 Pages

Objectives: Performance of emission measurements in the form of an acceptance test at the boiler plant of the type Turbomat 500 installed at the district heating plant Grieskirchen in accordance with § 23 FAV (BGBl. II No 331/1997).

TABLE OF CONTENTS

1. FORMULATION OF THE MEASUREMENT TASK

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 OPERATING COMPANY

Peasant Bio-Energy Fröling Heizkessel- und Behälterbau GesmbH, Parz 2, A-4710 Grieskirchen.

1.3 LOCATION

Peasant Bio-Energy Fröling Heizkessel- und Behälterbau GesmbH,
district heating plant, Parz 2, plot no 161/1, KG Parz, A-4710 Grieskirchen.

1.4 PLANT

The subject boiler (boiler 2) is a biomass heating plant of the make Fröling Heizkessel- und Behälterbau GesmbH, type Turbomat 500, with a nominal heat output of 500 kW and the objective of producing useful heat for the purpose of room heating and water heating.

The plant was approved from the regional administrative authority Grieskirchen by commercial authority notification with the reference number Ge20-47-2004 from 27.07.2004 (lit. 1).

Biomass in the forms mentioned below is generally fired in the subject boiler type Turbomat 500 in accordance with the manufacturer instruction.

- chipped wood (machine-hackled wood with and without bark, size G30 to G50, in accordance with ÖNORM M 7133)
- wooden pellets (d = 6mm)

Biomass in the form mentioned below is used presently in the biomass heating plant in accordance with the operator information.

- chipped wood (machine-hackled wood with and without bark, size G30 to G50)

A test of the furthermore in the boiler house of the district heating plant installed boiler of the make Urbas UR-FRR-2900 (boiler 1, nominal heat output 2900 kW) was not included in the subject task of the order.

The evaluation output of the entire plant is stated to a nominal heat output generated by fuel of 4 MW in accordance with the commercial authority notification (lit. 1).

1.5 DATE OF THE MEASUREMENTS

Date of the measurements: 27.04.2005 (acceptance test in accordance with § 23 FAV)
Date of the next measurements: 2008 (periodic emission measurement in a interval of 3 years)

1.6 REASON FOR THE MEASUREMENTS

Performance of emission measurements in the form of an acceptance test at the boiler plant of the type Turbomat 500 installed at the district heating plant Grieskirchen in accordance with § 23 FAV (BGBl. II No 331/1997, Austrian regulation concerning heating systems).

1.7 OBJECTIVES

Performance of emission measurements in the form of an acceptance test at the boiler plant of the type Turbomat 500 installed at the district heating plant Grieskirchen in accordance with § 23 FAV (BGBl. II No 331/1997, Austrian regulation concerning heating systems).

The tryouts should take place at the upper heat output range of the plant (nominal heat output) and at approx. 30 % of the heat output range of the biomass heating plant (partial load).

As test fuel the fuel wooden pellets should be fired, which is used in the boiler type Turbomat 500 in addition to the presently used fuel chipped wood.

The emission limit values underlying the evaluation of the emission behavior and the exhaust gas loss are mentioned below (limit values in accordance with FAV (BGBl. II No 331/1997)).

Parameter	limit values in accordance with FAV
Dust	50 mg/m³
Carbon monoxide (CO)	250 mg/m³
Nitrogen oxides (NO_x, shown as NO_2) - wood in natural state	250 mg/m³
Gaseous organic carbon substances (org. C, shown as carbon)	20 mg/m³
Exhaust gas loss at nominal heat output	≤ 19 %

With the emission measurements the content of dust, CO, NOx and OGC at nominal heat output and at partial load shall be determined in accordance with FAV at minimum three measured values as half-hour average values respectively in a test duration of at least 3 hours.

The emission limits are related to a dry flue gas basis at 13 % oxygen and standard condition at 0°C and 1013 mbar.
They are considered as per FAV as kept, if none of the determined half-hour average values exceed the emission limit value (minus the error margin of the measurement procedure, evaluation values).
The limit value for exhaust gas loss at nominal heat is calculated as arithmetic average value over the entire duration of test.

1.8 COMPONENTS TO BE MEASURED

- Dust
- Carbon monoxide (CO)
- Nitrogen oxides (NO and NO_2, shown as NO_2)
- Gaseous organic carbon substances (C)
- Exhaust gass loss

1.9 INDICATION WITH WHOM THE MEASUREMENT PLAN HAS BEEN AGREED

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

1.10 LIST OF ALL PERSONS WHO LOCALLY TOOK PART AT SAMPLING

On the part of TÜV Austria: Mr. Schrögendorfer (specialist)
On the part of the client: Mr. Hable, Mr. Mayr

1.11 PARTICIPATION OF FURTHER INSTITUTES

All tasks were performed by TÜV Austria.

1.12 TECHNICALLY RESPONSIBLE PERSONS

Eng. Mair, Tel. 0043-(0)7242/61383, direct dial 8208,
Eng. Pointner, Tel. 0043-(0)7242/61383, direct dial 8200.

2. DESCRIPTION OF THE PLANT

2.1 KIND OF PLANT

The subject boiler (boiler 2) is a biomass heating plant of the make Fröling Heizkessel- und Behälterbau GesmbH, type Turbomat 500, with a nominal heat output of 500 kW and the objective of producing useful heat for the purpose of room heating and water heating.
The plant was approved from the regional administrative authority Grieskirchen by commercial authority notification with the reference number Ge20-47-2004 from 27.07.2004 (lit. 1).

The evaluation output of the entire plant is stated to a nominal heat output generated by fuel of 4 MW in accordance with the commercial authority notification (lit. 1).

2.2 TECHNICAL DESCRIPTION OF THE PLANT, INPUT MATERIALS

The subject plant is a biomass heating plant of the make Fröling Heizkessel- und Behälterbau GesmbH, type Turbomat 500, with a nominal heat output of 500 kW and the objective of producing useful heat for the purpose of room heating and water heating.

Biomass in the forms mentioned below is generally fired in the subject boiler type Turbomat 500 in accordance with the manufacturer instruction.

- chipped wood (machine-hackled wood with and without bark, size G30 to G50, in accordance with ÖNORM M 7133)
- wooden pellets (d = 6mm)

The suction of the combustion air takes place between the boiler insulation and the air jacket boiler.

The injection of the combustion air takes place in the double air jacket which encloses the furnace (situated between fireclay and outer insulation). The partitioning of the combustion air in primary, secondary and tertiary air takes place by servo-motor controlled flaps.

The control of the air supply for combustion takes place by means of a lambda probe.

In the biomass heating system an exhaust gas heat exchanger is integrated in the flues after the firing.

Furthermore so called "Wirbulatoren" are installed for dust deposition, at which the dedusting is done automatically by a gear motor.

Additionally the boiler is provided with an exhaust gas recirculation (AGR), with which a part of the exhaust gas is sucked off by means of an RPM-regulated exhaust recirculation fan directly after the exhaust fan and afterwards it is fed into the primary and the secondary zone of the combustion.

The purified waste gases are ducted to the stack of the plant.

2.2.1 Technical data (as per boiler plate and/or per manufacturer information)

2.2.1.1 Boiler

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Type:	Turbomat 500
Production number:	500.0003.P.17
Year of construction:	2005
Maximum allowable operating pressure:	6 bar
Maximum allowable operating temperature:	110°C
Water content:	750 l
Boiler dimensions:	lxwxh =3.60x2.98x2.61 m
Boiler class:	3
Nominal heat output:	500 kW
Allowable fuels in accordance to dimensioning:	chipped wood (machine-hackled wood with and without bark, size G30 to G 50, in accordance with ÖNORM M 7133), as well as wooden pellets (d = 6mm)
Heat exchanger:	integrated in the boiler

2.2.1.2 Firing (retort)

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Type:	Turbomat 500
Construction:	stoker with reciprocating grate bars
Production number:	500.0003.P.06
Year of construction:	2005
Allowable fuels in accordance to dimensioning:	chipped wood (machine-hackled wood with and without bark, size G30 to G 50, in accordance with ÖNORM M 7133), as well as wooden pellets (d = 6mm)
Nominal heat output:	500 kW
Air supply for combustion:	primary, secondary and tertiary – controlled by means of a lambda probe
Fuel feeding:	optional hydraulic insertion or insertion per worm (here: hydraulic insertion)

2.2.1.3 Combustion air fan

Manufacturer of the motor:	company Dietz
Motor type:	DN 18
Engine power:	1.7 kW
Volume flow:	2280 m^3/h
Speed:	2840 min^{-1}

2.2.2 Appliances for the emission collection

Exhaust fan:

Manufacturer:	Klima Celje
Type:	106CV
Year of construction:	2005
Volume flow:	1.39-0.83 m^3/s
Speed:	2860 min^{-1}
Required output:	3.0 kW

2.2.3 Appliances for emission reduction

Exhaust gas recirculation (AGR)

Construction:	exhaust gas recirculation by means of an RPM-regulated exhaust gas fan
Reduced pollutants:	nitrogen oxides

Exhaust gas recirculation fan:

Manufacturer:	Klima Celje
Type:	104CVX224/4
Year of construction:	2005
Volume flow:	0.49 m^3/s
Speed:	2860 min^{-1}
Required output:	1.5 kW

WOS (efficiency optimization system):

Construction:	Wirbulatoren
Reduced pollutants:	dust, exhaust gas loss

2.2.4 Data of emission source

Construction:	stainless steel
Number of stack drafts:	1
Connected boilers:	biomass boiler make Fröling
Stack height over ground:	approx. 21 m
Diameter:	D = 0.35 m
Sectional area:	A = 0,096 m^2

3. DESCRIPTION OF THE SAMPLING POINTS

The sampling took place on the measuring points mentioned below.

Exhaust gas loss and gaseous pollutants

The measuring point was situated in the vertical flue gas pipe directly after the exhaust fan.

Dust and flue gas volume

The sampling for the determination of the dust concentration of the flue gases and the flue gas volume took place from the horizontal flue gas pipe between the flue exit of the boiler and the stack.

Length of the straight inlet:	approx. 1.5 m
Length of the straight outlet:	approx. 1.4 m
Circular cross section:	D = 0.35

4. PERFORMANCE OF THE MEASUREMENTS

4.1 BASES

- Accreditation decree of the Minister of Economics and Labour, No. 92714/206-I/12/03, issued at May 07, 2003, valid from 06.07.2001.

- Quality assurance system of the TÜV Austria.

- Notification of the regional administrative authority Grieskirchen, reference number Ge20-47-2004 from 27.07.2004; lit. 1.

- BGBl. II No. 331/1997 – "331. Federal Law Gazette of the Minister of Economic Matters on the construction, the mode of operation, the equipment and the permissible extent of the emission from units to the firing of solid, liquid and gaseous fuels in commercial plants (regulation concerning heating systems – FAV), November, 18, 1997.

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

- ÖNORM M 9415 "Measuring technique; Measurement of the emission of substances into the atmosphere", 01.01.2004.

- VDI 2456, Part 5 - "Gaseous emission measurement; measurement of nitrogen monoxide; chemiluminescence unit; thermo electron model 10;" May 1978. "

- VDI 2456, Part 6 - "Gaseous emission measurement; determination of the sum of nitrogen monoxide and nitrogen dioxide as nitrogen monoxide by use of a converter;" May 1978.

- VDI 2459, Part 6 - "Gaseous emission measurement; measurement of carbon monoxide concentration; non-dispersive infrared absorption method"; November 1980.

- VDI 2066, Part 1 - "Particulate matter measurement; measuring of particulate matter in flowing gases; gravimetric determination of dust load; Oversight", October 1974.

- VDI 2066, Part 7 - "Measurement of particulate matter, manual dust measurement in flowing gases; gravimetric determination of dust load; plane filter devices"; August 1993.

- ÖNORM EN 12619 – "Stationary source emissions – Determination of the mass concentration of total gaseous organic carbon at low concentration in flue gases – Continous flame ionisation detector method"; 01.01.1997.

- VDI 3481, Part 1 - "Gaseous emission measurement; determination of hydrocarbon concentration; flame-ionization-detector (FID);" August 1975 (historical document, further applicable document).

- DIN 1942 - "Acceptance test code for steam generators (VDI-rules for steam generators); February 1994.

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

- DIN 51718 – "Testing of solid fuels – Determination of the water content and the moisture of analysis sample"; 01.06.2002.

- DIN 43710 - "Measurement and control; electrical temperature sensors, reference tables and materials of thermocouples"; September 77.

4.2 MEASUREMENT AND ANALYTICAL METHODS, APPARATUS

4.2.1 Flue gas boundary conditions

4.2.1.1 Flue gas velocity

Measuring Method:	determination of differential pressure between dynamic pressure and static pressure in the flue gas pipe
Guideline:	VDI 2066, Part 1 and VDI/VDE 2640, Part 3
Instrument:	Prandtl´s pitot tube in combination with a calibrated micromanometer
Manufacturer:	Special Instruments
Type:	Digima FP auto zero
Range:	0 – 5 hPa
Uncertainty:	± 5 % of the measured value

4.2.1.2 Static pressure in the flue gas pipe

Measuring Method:	determination of differential pressure between static pressure in the flue gas pipe and ambient pressure
Guideline:	VDI 2066, Part 1
Instrument:	Prandtl´s pitot tube in combination with a calibrated micromanometer, see point 4.2.1.1

4.2.1.3 Air pressure at the height of the sampling point

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

4.2.1.4 Flue gas temperature, combustion air temperature

Measuring method:	thermoelectric
Guideline:	DIN 43710
Instrument:	Fe-Cu-Ni thermocouple with a digital display instrument
Manufacturer:	Mesa Electronic
Type:	A009.411.40.40
Uncertainty:	range ≤ 150°C: ± 3°C range > 150°C: ± 2 % of the measured value

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

Measuring method:	two-thermometer-method
Instrument:	psychrometer
Uncertainty:	± 10 % of the measured value

4.2.1.6 Flue gas density

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 in the duct.

4.2.1.7 Flue gas volume

Calculated taking into account the results of the points 4.2.1.1 to 4.2.1.6.

4.2.2 Gaseous and vapourous emissions

4.2.2.1 Continuously recorded measurement instruments

O_2	Manufacturer:	Servomex
	Type:	OA570
	Measurement method:	paramagnetism
	Range:	0-25 % of vol.
	Uncertainty:	± 0.2 % of vol.
CO		
	Manufacturer:	Siemens
	Type:	Ultramat 22P
	Measurement method:	non-dispersive infrared absorption
	Range:	0-1000 ppm
	Uncertainty:	range up to 100 ppm: ± 2 ppm range 100-1000 ppm: ± 2 % of the measured value
CO_2:	Manufacturer:	Siemens
	Type:	Ultramat 22P
	Measurement method:	non-dispersive infrared absorption
	Range:	0-20 % of vol.
	Uncertainty:	± 0.2 % of vol.
NO_x	Manufacturer:	Monitor Labs
	Type:	Model 8840
	Measurement method:	chemiluminescence
	Converter:	stainless steel converter (thermostated on 750°C)
	Used range:	0-500 ppm
	Uncertainty:	± 1.5 % of range performance
C	Manufacturer:	Testa
	Type:	FID 123
	Measurement method:	flame ionisation
	Used ranges:	0-100 ppm C_3H_8
	Uncertainty:	± 1.5 % of range performance

4.2.2.2 Measurement location design

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

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

Sampling line 1 before gas conditioning:

Manufacturer:	Winkler
Material/heating:	teflone, heated on 180°C
Length:	5 m
Inside diameter:	4 mm
Outside diameter:	6 mm

After the sampling line 1 the sampled flue gas was divided after the gas conditioning by using a glass T-fitting in the sampling lines mentioned below:

- sampling line 2: for determination of the concentration of C
- sampling line 3: for determination of the concentrations of O_2, CO, CO_2 and NO_x

Sampling line 2:	Manufacturer:	Winkler
	Material/heating:	teflone, unheated
	Length:	0.1 m
	Inside diameter:	4 mm
	Outside diameter:	6 mm
Sampling line 2:	Manufacturer:	Winkler
	Material/heating:	teflone, unheated
	Length:	0.1 m
	Inside diameter:	4 mm
	Outside diameter:	6 mm

Gas conditioning: combined suction, filter, cooling and controling unit

Manufacturer:	M & C
Type:	PSS 10-1
Material cooler:	glass
Temperature cooler:	approx. 4°C
Condensate removal:	automatically

Sampling line 4 after gas conditioning:

Material/heating:	Teflon, unheated
Length:	approx. 20 m
Inside diameter:	4 mm
Outside diameter:	6 mm

4.2.2.3 Recording of the measured values

Logging software:	software Dasylab, company Dewetron
Module:	ISM 100 intelligent sensor module V.2.O., company Gantner
Scanning rate:	1 second
Resolution A/D-transducer:	16 bit
Uncertainty:	± 0.3 % of the measured value

4.2.2.4 Adjustment of the measurement instruments

Before starting the test periods the reference points of the gas analysis instruments were adjusted by feeding test gases of the companies Siad and Messer Austria mentioned below.

Parameter	Test gas concentration as per certificate of analysis	Manufacturer	Tolerance of test gas analysis in accordance with the manufacturers specification
CO	800 ppm CO	Siad VTG	± 2 % of test gas concentration
CO_2	16.25 % of vol. CO_2	Siad VTG	± 2 % of test gas concentration
NO_x	390 mg NO/m^3	Siad VTG	± 2 % of test gas concentration
C	93.0 ppm C_3H_8	Messer Austria	± 2 % of test gas concentration

4.2.2.5 Check of the instrument characteristic

In accordance with the quality assurance manual of the TÜV Austria the check of the instrument characteristics is done once a year. Recordings can be looked into in the test centre Thalheim/Wels.

4.2.2.6 Response time of the overall measuring apparatus

The response time (t_{90} – time) for the slowest operating component (NO_x) amounted to 93 seconds and was determined by the time which was needed by bringing the probe into the duct up to reaching 90 % of the final value.

4.2.3 Particulate emissions

4.2.3.1 Dust

Sampling probe:	titanium, heated by flue gas
Position of the filter holder:	internal in 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 6 days
Uncertainty:	in the range above 10 mg/m³: ± 5 % of the measured value
Sampling and analysis:	in accordance to ÖNORM M 5861-1
Drying temperature of the collection medium	
before exposure:	110 °C
after exposure:	110 °C
Drying time of the collection medium (equilibration)	
before and after exposure:	approx. 24 hours (in the dessiccator)
Gas volume meter for the determination of the flue gas sucked off during dust sampling:	
Manufacturer:	Elster
Type:	dry design, G 2,5
Commerce error limit:	± 4 % of the measured value
Analysis balance: Manufacturer:	Mettler
Type:	AE 163
Graduation:	0.01 mg

The leakage test of the apparatus for dust measurement took place via applying a vacuum before the performance of the single measurements.

The oxygen concentration at the measuring point of dust took place after sampling gas drying by silica gel with an oxygen meter of the type OA 570, company Servomex (see point 4.2.2.1).

4.3 WATER CONTENT OF THE FUEL

At the day of the measurements a sample of the fuel was taken by the specialist of the TÜV Austria (Mr. Schrögendorfer).

The determination of the water content of the fuel sample took place via drying process in a drying oven in accordance to DIN 51718 in the test centre Thalheim/Wels of the TÜV Austria.

4.4 CALCULATION OF THE EXHAUST GAS LOSS

The exhaust gas loss of the biomass heating system was calculated by the formalism mentioned below in accordance to the 331. Federal Law Gazette of the Minister of Economic Matters on the construction, the mode of operation, the equipment and the permissible extent of the emission from units to the firing of solid, liquid and gaseous fuels in commercial plants (regulation concerning heating systems – FAV) from 18.11.1997:

Exhaust gas loss (%) $q_A = (t_A - t_L) \cdot [A_2/(21 - O_2) + B]$

t_A..... exhaust gas temperature °C
t_L..... combustion air temperature in °C
O_2..... dry oxygen content of the flue gas in % of vol.
A_2..... 0.6622 for biomass with a water content of 4.5 %
B..... 0.0099 for biomass with a water content of 4.5 %

The input data used for the calculation of the exhaust gas loss at the measuring point after the exhaust fan are mentioned in point 6.1.

5. OPERATING CONDITIONS OF THE PLANT DURING THE MEASUREMENTS

The biomass heating plant became fired at the upper heat output range of the plant (nominal heat output) and at approx. 30 % of the heat output range (partial load) at the day of the measurements.

As fuel wooden pellets was fired at the day of the measurements, which is used in the boiler type Turbomat 500 in addition to the presently used fuel chipped wood in accordance with the manufacturer specification (diameter: 6 mm, maximum length: 4 cm, w = 4.5 %, supplier company Sturmberger).

The water content of the test fuel was determined by analysis of a fuel sample which was taken at the day of the measurements and the result was 4.5 % of mass (analysis by TÜV Austria, see point 4.3 and 6.7).

The determination of the fuel mass fed to the furnace of the biomass heating plant took place through representatives of the client via weighing with an electronical balance of the make UWE CS-3000 which was provided by the client.

For this purpose the fuel feeding system from the dump, which is normally installed at the plant, was deactivated and the cross conveyor of the hydraulic insertion was filled manually with weighed amounts of fuel from metal boxes with a nominal content of 0.5 m^3 by means of a forklift.

The useful heat output of the boiler was determined by the heat meter of the boiler 2 which was installed at the plant.

Technical data of the heat meter – boiler 2

Manufacturer:	Kamstrup
Type:	66C03B1372
Production number:	4733840/2004
Programme:	44120120
Temperature sensor:	Pt 500
Nominal diameter:	DN 80
Maximum flow:	15 m^3/h
Impulse division:	10 impulses / l

The operating conditions of the boiler plant during the measurement period are shown below.

Fuel wooden pellets (diameter: 6 mm, maximum length: 4 cm, w = 4.5 %)

Parameter	Nominal heat output	Partial load
Date of measurements	27.04.2005	27.04.2005
Measuring time (from – to)	11:54-14:16	15:58-17:39
Boiler temperature (°C)	84	81
Combustion chamber temperature (°C)	1184	1080
Negative pressure in the combustion chamber (Pa)	46	134
Feed (%)	94.1	19.3
Stoker cycle time (s)	100	100
Primäry air (%)	100 [1)]	56 [2)]
Secondary air (%)	81 [3)]	3 [4)]
Tertiäry air (%)	59	48
Exhaust gas recirculation position AGR (%)	28	42
Exhaust gas recirculation AGR secondary (%)	54	25
Heat output useful generated (kW)	503	140
Fuel mass added (kg/h)	120	33

[1)] ... 0-100 % = 0.4-3.0 V [2)] ... 0-100 % = 0.4-2.8 V [3)] ... 0-100 % = 0.5-10 V [4)] ... 0-100 % = 0.5-10 V

6. MEASUREMENT RESULTS

All mentioned pollutant concentrations are related to a dry flue gas basis at 0°C, 1013 hPa at actual oxygen content and calculated on a hypothetical oxygen content of 13 % O_2 and they are given as average values in the dimension mg/m³ over the mentioned measuring periods.

Measurement uncertainties are given as measured value ± estimated measurement uncertainty of the value for the whole procedure.

With „<" marked values represent the relative detection limits of the used measurement instruments.

6.1 FLUE GAS BOUNDARY CONDITIONS

Measuring point after exhaust fan	Nominal heat output	Partial load
Date of measurements:	27.04.2005	27.04.2005
Measuring time (from – to):	11:54-14:16	15:58-17:39
Oxygen concentration (% of vol.):	9.9 ± 0.2	12.2 ± 0.2
Carbon dioxide concentration (% of vol.):	10.7 ± 0.2	8.5 ± 0.2
Combustion air temperature (°C):	20 ± 3	21 ± 3
Flue gas temperature (°C):	150 ± 3	97 ± 3

Measuring point dust	Nominal heat output	Partial load
Date of measurements:	27.04.2005	27.04.2005
Measuring time (from – to):	11:54-14:16	15:58-17:39
Oxygen concentration (% of vol.):	9.9 ± 0.2	12.2 ± 0.2
Air pressure at the height of the sampling point (hPa):	973 ± 1	974 ± 1
Flue gas temperature (°C):	139 ± 3	89 ± 3
Flue gas humidity (kg/m³):	0.09 ± 0.01	0.07 ± 0.01
Flue gas velocity (m/s):	5.0 ± 0.3	1.6 ± 0.1
Flue gas volume, at actual oxygen concentration *		
- operating condition (m³/h):	1730 ± 170	550 ± 60
- humid (m³/h, 0°C, 1013 hPa):	1100 ± 110	400 ± 40
- dry (m³/h, 0°C, 1013 hPa):	990 ± 100	370 ± 40

* ... rounded off to ± 10 m³/h

6.2 DUST

Nominal heat output – wooden pellets

Date	Measuring time	Dust concentration related to		actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	11:54-12:24	50 ± 3	32 ± 2	8.4 ± 0.2
	12:31-13:01	23 ± 1	19 ± 1	11.4 ± 0.2
	13:09-13:39	19 ± 1	13 ± 1	9.7 ± 0.2
	13:46-14:16	24 ± 1	17 ± 1	9.9 ± 0.2
Average		29 ± 1	20 ± 1	9.9 ± 0.2

Partial load – wooden pellets

Date	Measuring time	Dust concentration related to		Actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	15:58-16:28	15 ± 1	14 ± 1	12.2 ± 0.2
	16:35-17:05	18 ± 1	16 ± 1	11.9 ± 0.2
	17:09-17:39	16 ± 1	15 ± 1	12.4 ± 0.2
Average		16 ± 1	15 ± 1	12.2 ± 0.2

6.3 CARBON MONOXIDE (CO)

Nominal heat output – wooden pellets

Date	Measuring time	CO concentration related to		actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	11:54-12:24	9 ± 4	6 ± 3	8.4 ± 0.2
	12:31-13:01	9 ± 4	8 ± 4	11.4 ± 0.2
	13:09-13:39	9 ± 4	6 ± 3	9.7 ± 0.2
	13:46-14:16	8 ± 4	6 ± 3	9.9 ± 0.2
Average		9 ± 4	7 ± 3	9.9 ± 0.2

Partial load – wooden pellets

Date	Measuring time	CO concentration related to		actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	15:58-16:28	17 ± 4	15 ± 4	12.2 ± 0.2
	16:35-17:05	14 ± 4	12 ± 4	11.9 ± 0.2
	17:09-17:39	19 ± 4	18 ± 4	12.4 ± 0.2
Average		17 ± 4	15 ± 4	12.2 ± 0.2

6.4 NITROGEN OXIDES (NO_x)

The sum of nitrogen oxides (NO_x), measured as sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), is calculated and shown as nitrogen dioxide (NO_2).

Nominal heat output – wooden pellets

Date	Measuring time	NOx concentration related to		actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	11:54-12:24	243 ± 12	154 ± 8	8.4 ± 0.2
	12:31-13:01	198 ± 10	165 ± 8	11.4 ± 0.2
	13:09-13:39	203 ± 10	144 ± 3	9.7 ± 0.2
	13:46-14:16	203 ± 10	146 ± 7	9.9 ± 0.2
Average		212 ± 11	152 ± 8	9.9 ± 0.2

Partial load – wooden pellets

Date	Measuring time	NOx concentration related to		actual O_2-concentration
		actual O_2	13 % O_2 of vol.	
	from – to	mg/m³	mg/m³	% of vol.
27.04.2005	15:58-16:28	149 ± 7	135 ± 7	12.2 ± 0.2
	16:35-17:05	160 ± 8	141 ± 7	11.9 ± 0.2
	17:09-17:39	147 ± 7	137 ± 7	12.4 ± 0.2
Average		152 ± 8	138 ± 7	12.2 ± 0.2

6.5 GASEOUS ORGANIC CARBON SUBSTANCES (C)

The determination of gaseous organic carbon substances (C) was performed without splitting the individual components with a flame ionisation detector (FID).
For the adjusting of the reference point of the flame ionisation detector propane was used.

The concentration of gaseous organic carbon substances are given calculated as carbon (C) in the dimension mg/m³.

Nominal heat output – wooden pellets

Date	Measuring time from – to	C concentration related to actual O_2 mg/m³	C concentration related to 13 % O_2 of vol. mg/m³	actual O_2-concentration % of vol.
27.04.2005	11:54-12:24	< 3	< 2	8.4 ± 0.2
	12:31-13:01	< 3	< 3	11.4 ± 0.2
	13:09-13:39	< 3	< 3	9.7 ± 0.2
	13:46-14:16	5 ± 3	4 ± 2	9.9 ± 0.2
Average		≤ 4	≤ 3	9.9 ± 0.2

Partial load – wooden pellets

Date	Measuring time from – to	C concentration related to actual O_2 mg/m³	C concentration related to 13 % O_2 of vol. mg/m³	actual O_2-concentration % of vol.
27.04.2005	15:58-16:28	< 3	< 3	12.2 ± 0.2
	16:35-17:05	< 3	< 3	11.9 ± 0.2
	17:09-17:39	< 3	< 3	12.4 ± 0.2
Average		< 3	< 3	12.2 ± 0.2

6.6 EXHAUST GAS LOSS

The exhaust gas losses of the heating plant calculated by the formalism in accordance to the BGBl. II No 331/1997 (FAV, see point 4.4), are mentioned below.
The input data used for the calculation which were measured at the measuring point after exhaust fan are given in point 6.1 of the test report.

t_A..... exhaust gas temperature °C
t_L..... combustion air temperature in °C
O_2..... dry oxygen content of the flue gas in % of vol.
A_2..... 0.6622 for biomass with a water content of 4.5 %
B..... 0.0099 for biomass with a water content of 4.5 %

Calculated exhaust gas losses

Nominal heat output – fuel wooden pellets: q_A = 9.0 % ± 0.4 %
Partial load – fuel wooden pellets: q_A = 6.5 % ± 0.3 %

6.7 WATER CONTENT OF THE FUEL

At the day of the measurements a sample of the fuel was taken by the specialist of the TÜV Austria (Mr. Schrögendorfer).

The determination of the water content of the fuel sample took place via drying process in a drying oven in accordance to DIN 51718 in the test centre Thalheim/Wels of the TÜV Austria.

The water content determined within the fuel analysis was 4.5 ± 1.5 % of mass.

6.8 PLAUSIBILITY CHECK

The plausibility for the continuously recorded substances has taken for granted by feeding zero and span gas to the analysis instruments before starting and after finishing the test periods.

A leakage test of the sampling appliance for the continous measurements as well as the apparatus for the discontinous measurements took place via applying a vacuum before the performance of the single measurements.

In consideration of the accuracy and the uncertainty of the used measurement procedures, the applied measuring instruments and the operating condition of the plant no implausibility did occur.

7. SUMMARY

The Fröling Heizkessel- und Behälterbau GesmbH assigned the TÜV Austria with the performance of emission measurements in the form of an acceptance test at the boiler plant of the type Turbomat 500 installed at the district heating plant Grieskirchen in accordance with § 23 FAV (BGBl. II No 331/1997, Austrian regulation concerning heating systems).

At the day of the measurements the tryouts took place at the biomass heating plant at the upper heat output range of the plant (nominal heat output) and at approx. 30 % of the heat output range (partial load).

As fuel wooden pellets was fired at the day of the measurements, which is used in the boiler type Turbomat 500 in addition to the presently used fuel chipped wood in accordance with the manufacturer specification (diameter: 6 mm, maximum length: 4 cm, w = 4.5 %, supplier company Sturmberger).

The measurement results of the emission measurements, performed at 27.04.2005, are stated summarised below.

The declaration of the determined concentrations of the substances occurs related to a dry flue gas basis at 0°C, 1013 hPa and calculated on a hypothetical oxygen content of 13 % O_2.

The detailed results are mentioned in point 6 of this test report.

The emission limit values underlying the evaluation of the emission behavior and the exhaust gas loss are mentioned in point 1.7 of the test report (limit values in accordance with FAV (BGBl. II No 331/1997, Austrian regulation concerning heating systems)).

Measurement results at nominal heat output, fuel wooden pellets

Parameter	Average	Maximum HMW	Evaluation value
Dust (mg/m³)	20 ± 1	32 ± 2	30
Carbon monoxide (CO, mg/m³)	7 ± 3	8 ± 4	4
Nitrogen oxides (NO_x shown as NO_2, mg/m³)	152 ± 8	165 ± 8	157
Gaseous organic carbon substances (C, mg/m³)	≤ 3	4 ± 2	2
Exhaust gas loss (%)	9.0 ± 0.4	-	8.6

HMW ... half-hour average value

Measurement results at partial load, fuel wooden pellets

Parameter	Average	Maximum HMW	Evaluation value
Dust (mg/m³)	15 ± 1	16 ± 1	15
Carbon monoxide (CO, mg/m³)	15 ± 4	18 ± 4	14
Nitrogen oxides (NO_x shown as NO_2, mg/m³)	138 ± 7	141 ± 7	134
Gaseous organic carbon substances (C, mg/m³)	< 3	< 3	< 3
Exhaust gas loss (%)	6.5 ± 0.3	-	6.2

HMW ... half-hour average value

7.1 INTERPRETATION OF THE MEASUREMENT RESULTS

In the context of the emission measurements, which were performed at the biomass heating plant of the type Turbomat 500 of the make Fröling Heizkessel- und Behälterbau GesmbH on 27.04.2005, the emission limit values stated in the FAV (BGBl. II No 331/1997, Austrian regulation concerning heating systems) has been kept.

As fuel wooden pellets was fired at the day of the measurements, which is used in the boiler type Turbomat 500 in addition to the presently used fuel chipped wood in accordance with the manufacturer specification (diameter: 6 mm, maximum length: 4 cm, w = 4.5 %, supplier company Sturmberger).

The emission limit values are considered to be kept in accordance to FAV, because none of the determined evaluation values (maximum half-hour average minus the error margin of the measurement procedure) has exceeded the emission limit value.

TÜV Austria
Test centre Wels
Division Environmental Technology and Chemistry
The authorized signatory:

Eng. G. Schrögendorfer