

Fröling
Heizkessel- und Behälterbau GesmbH

Industriestraße 12
A-4710 Grieskirchen

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Order by Mr. Gruber	01/07/2010	10-UW/Wels-EX-242/1 SD/SD	09/05/2011

Subject: Type test of the pellets boiler type P4 Pellet 100 in accordance with ÖNORM EN 303-5:1999

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TÜV®



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

R E P O R T

of the accredited testing laboratory and inspection body

concerning the tests performed in the period of 18/10/2010 – 05/11/2011

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Test report no.:	10-UW/Wels-EX-242/1
Test report date:	09/05/2011

Report concerning the type test of the pellets boiler type P4 Pellet 100,
in accordance with ÖNORM EN 303-5:1999

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

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

Test place: Fröling Heizkessel- und Behälterbau GesmbH, test rig,
Industriestraße 12, A-4710 Grieskirchen

Type of testing: Type test of a biomass heating system

Order number: Order via email by Mr. Gruber

Date of order: 01/07/2010

Day of testing: 18/10/2010 – 05/11/2010

Contents: 48 pages
5 enclosures

Task: Type test of the pellets boiler type P4 Pellet 100, in accordance with ÖNORM EN 303-5:1999.

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- Enclosure 4: Diagram of the operating conditions of the system during the period of type test
- Enclosure 5: List of test documents submitted to TÜV AUSTRIA SERVICES GMBH by the boiler manufacturer.

1. TASK DEFINITION

1.1 CLIENT

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

Contact: Mr. Hager, Mr. Gruber

Telephone number: 0043-(0)7248-606-0

1.2 MANUFACTURER

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

1.3 LOCATION / TEST

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

1.4 UNIT

The unit in question is a biomass heating system of the make Fröling, type P4 Pellet 100, with a nominal heat output of 100 kW and with the objective of producing useful heat for the purpose of room heating and water heating.

Currently the unit is covered in Austria by regulations of ÖNORM EN 303-5:1999 and Austrian law regulations (art. 15a B-VG "Vereinbarung über Schutzmaßnahmen betreffend Kleinf Feuerungen" and "Vereinbarung über die Einsparung von Energie", and at industrial facilities the regulation concerning heating systems (BGBl. II No. 331/1997, FAV)).

As per manufacturer information the heating boiler is designed for firing wood pellets (in accordance to ÖNORM M 7135 HP1 respectively DIN 51731 HP5).

1.5 DATE OF TESTS

The type test was performed during the period from 18/10/2010 – 05/11/2010.

The exact measuring times are listed with the measurement results.

1.6 CAUSE OF TEST

- (a) Implementation of the type test in accordance with ÖNORM EN 303-5:1999.
- (b) Verification of the compliance with the applicable regulations of the agreement of the Austrian Federal States according to article 15a of the Federal Constitution about "Schutzmaßnahmen betreffend Kleinf Feuerungen" and about "Einsparung von Energie" at test time.
- (c) Verification of the compliance with the applicable regulations of the Austrian Federal Law Gazette Part II No. 331/1997 (FAV, BGBl. II No. 331/1997, regulation concerning heating systems) at test time.

1.7 DEFINITION OF TASK

- (a) Type test performance in accordance with ÖNORM EN 303-5:1999.
- (b) Verification of the compliance with the applicable regulations of the agreement of the Austrian Federal States according to article 15a of the Federal Constitution about "Schutzmaßnahmen betreffend Kleinf Feuerungen" and about "Einsparung von Energie" at test time.
- (c) Verification of the compliance with the applicable regulations of the Austrian Federal Law Gazette Part II No. 331/1997 (FAV, BGBl. II No. 331/1997, regulation concerning heating systems) at test time.

Furthermore, in the context of the type test, a determination of the auxiliary power consumption should be done in the following modes of operation and key consumers:

- Nominal heat output (average value, measuring time ≥ 6 h)
- Minimum heat output (average value, measuring time ≥ 6 h)
- Sleeping operation (average value, measuring time ≥ 10 min)
- Ignition process (electrical work)
- Key consumers
 - fan motor
 - motor for cleaning heating surfaces and to discharge flue ash
 - fuel discharge (suction device)
 - stoker screw conveyor
 - back-burning damper motor

The tests should take place at the test rig which is set up at the Fröling Heizkessel- und Behälterbau GesmbH, which was equivalent with the requirements of ÖNORM EN 303-5 at test date.

As test fuel the fuel wood pellets should be fired, which is used as manufacturer information in the biomass boiler type (according to ÖNORM M 7135 respectively DIN 51731 HP5).

1.7.1 Emission limit values and requirements of boiler efficiencies

The emission limit values for the evaluation of emission behaviour and boiler efficiency in Austria at test time are listed below.

Regulatory requirements in other countries and possible aid regulations have to be considered in addition. They are not especially mentioned in this report.

Limit values in accordance with ÖNORM EN 303-5:1999, including deviations from Austria

Parameter	Limit values in accordance with ÖNORM EN 303-5:1999, boiler class 3 (related to 10 % O ₂)	Limit values in accordance with ÖNORM EN 303-5:1999, deviations from Austria
Dust	150 mg/m ³	60 mg/MJ
Carbon monoxide (CO)	2500 mg/m ³	500 mg/MJ
Nitrogen oxides (NO _x , shown as NO ₂)	-	150 mg/MJ
Organic gaseous substances (OGC, shown as carbon)	80 mg/m ³	40 mg/MJ
Boiler efficiency	≥ 79.0 % ($67 + 6 \log Q_N$)	≥ 83.7 % ($65.3 + 7.7 \log Q_N$)

Q_N ... nominal heat output

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The emission limits for CO, NO_x and OGC are considered as arithmetic mean values of the emission over the entire test period (test duration at nominal heat output and test duration at minimum heat output shall be at least 6 hours, all determined emissions are related to a dry flue gas basis at standard condition at 0°C and 1013 hPa, respectively referred to the energy content of the test fuel).

To determine the dust content the test period has to be divided into at minimum 4 equal time sections as defined in ÖNORM EN 303-5:1999.

The measurements shall begin in each case at the start of the sections, with the first measurement taken when the test begins. The suction time per filter is limited to 30 min. The average dust content is determined from the 4 half-hour values at minimum.

At minimum heat output only the proof of keeping the emission limit values for CO and OGC is required.

The limit value for the boiler efficiency is calculated as arithmetic mean value over the entire test duration.

Limit values in accordance with the regulations of the agreement of the Austrian Federal States according to article 15a (art. 15a B-VG) of the Federal Constitution about "Schutzmaßnahmen betreffend Kleinf Feuerungen" and about "Einsparung von Energie" at test time

Parameter	Limit values in accordance with art. 15a B-VG
Dust	60 mg/MJ
Carbon monoxide (CO)	500 mg/MJ
Nitrogen oxides (NO _x , shown as NO ₂)	150 mg/MJ
Organic gaseous substances (OGC, shown as carbon)	40 mg/MJ
Boiler efficiency	≥ 83.7 % (65.3 + 7.7logQ _N)

Q_N ... nominal heat output

The emission limits for CO, NO_x and OGC are given as arithmetic mean values of the emission over the entire test period (test duration at nominal heat output and test duration at minimum heat output shall be at least 3 hours, all emission limits are related to the energy content of the test fuel).

The emission value for dust is the arithmetic average value determined from at minimum 3 half-hour values during the test period.

At minimum heat output only the proof of keeping the emission limit values for CO and OGC is required.

The limit value for the boiler efficiency is calculated as arithmetic mean value over the entire test duration.

Limit values in accordance with the Austrian Federal Law Gazette Part II No. 331/1997 (FAV, BGBl. II No. 331/1997, regulation concerning heating systems)

The emission limit values for the evaluation of the emission behaviour and the exhaust gas loss (loss through sensible heat of the products of combustion) at nominal heat output at test time are mentioned below (limit values in accordance with FAV, (BGBl. II No 331/1997)).

Parameter	limit values in accordance with FAV
Dust	150 mg/m ³
Carbon monoxide (CO)	800 mg/m ³
Nitrogen oxides (NO _x , shown as NO ₂)	250 mg/m ³
Organic gaseous substances (OGC, shown as carbon)	50 mg/m ³
Exhaust gas loss at nominal heat output	≤ 19 %

During the emission measurements the content of dust, CO, NO_x and OGC at nominal heat output and at minimum heat output shall be determined at minimum from three measured values as half-hour average values in 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 hPa.

The limit values are complied, if none of the determined half-hour average values exceeds the emission limit value.

The limit value for the exhaust gas loss is calculated as arithmetic mean value over the entire test duration.

1.8 COORDINATION

Coordination regarding date, measuring scope and procedure took place with Mr. Gruber as representative of the client in the period before the measurements.

1.9 PARTICIPANTS IN THE ON-SITE SAMPLING AND TESTING

On the part of TÜV AUSTRIA SERVICES GMBH: Mr. Schrögendorfer
On the part of the manufacturer: Mr. Gruber, Mr. Hinterberger

1.10 PARTICIPATION OF FURTHER INSTITUTES

None. All performances had been done by TÜV AUSTRIA SERVICES GMBH.

1.11 TECHNICALLY RESPONSIBLE PERSONS

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Mr. Schrögendorfer, t: 07242/61383 direct dial 8215, e: sd@tuv.at.

1.12 BASES

1.12.1 Standards of the accredited testing laboratory and supervisory board

- Accreditation decree of TÜV AUSTRIA SERVICES GMBH, issued by the Austrian Minister of Economics and Labour, No. 92.714/0695-I/12/2008 from 13.01.2009.
- 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 in the accredited scope of the inspection body).
- ÖNORM M 5861-1 - "Manual determination of particle concentrations in fluid gases; Gravimetric Method, General requirements"; 01.04.1993.
- VDI 2066, Part 1 - " Particulate matter measurement - Dust measurement in flowing gases - Gravimetric determination of dust load"; 01.11.2006.
- 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 (NO_x) - 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.
- ISO 12039 - " Stationary source emissions - Determination of carbon monoxide, carbon dioxide and oxygen - Performance characteristics and calibration of automated measuring systems"; 01.06.2001.
- 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 51732 - " Testing of solid mineral fuels - Determination of total carbon, hydrogen and nitrogen - Instrumental methods"; 01.08.2007.
- DIN 51900, part 1 - " Testing of solid and liquid fuels - Determination of gross calorific value by the bomb calorimeter and calculation of net calorific value - Part 1: Principles, apparatus, methods"; 01.04.2000.
- DIN 51900, part 3 - " Testing of solid and liquid fuels - Determination of gross calorific value by the bomb calorimeter and calculation of net calorific value - Part 3: Method using adiabatic jacket"; 01.01.2005.

1.12.2 Other bases

- Quality assurance system of TÜV AUSTRIA SERVICES GMBH.
- ÖNORM EN 304 - " Heating boilers - Test code for heating boilers for atomizing oil burners (EN 304:1992 + A1:2000 + A2:2003)"; 01.02.2005.
- BGBl. II No. 331/1997 – "331. Federal Law Gazette of the Minister of Economic Affairs 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), 18.11.1999.
- OÖ LGBl. 56/1995 – "Agreement according to article 15 a B-VG about "Schutzmaßnahmen betreffend Kleinf Feuerungen"", 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 M 7510-4 – " Verification of heating systems - Part 4: Simple verification of firing systems for solid fuels", 01.11.2009.
- 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 4702, part 2 - " Central heating boilers; test code"; 01.03.1990.
- DIN 1942 - " Acceptance test code for steam generators"; 01.02.1994 (historical document).
- Test documents, drawings, operating instructions and installation instructions from Fröling Heizkessel- und Behälterbau GesmbH for the pellets boiler type P4 Pellet 100.

2. DESCRIPTION OF THE UNIT

2.1 KIND OF UNIT

The unit in question is a biomass heating system of the make Fröling, type P4 Pellet 100, with a nominal heat output of 100 kW and with the objective of producing useful heat for the purpose of room heating and water heating.

Currently the unit is covered in Austria by regulations of ÖNORM EN 303-5:1999 and Austrian law regulations (art. 15a B-VG "Vereinbarung über Schutzmaßnahmen betreffend Kleinf Feuerungen" and "Vereinbarung über die Einsparung von Energie", and at industrial facilities the regulation concerning heating systems (BGBl. II No. 331/1997, FAV)).

As per manufacturer information the heating boiler is designed for firing wood pellets (in accordance to ÖNORM M 7135 HP1 respectively DIN 51731 HP5).

2.2 TECHNICAL DESCRIPTION OF THE UNIT

The unit in question is a biomass heating system of the make Fröling, type P4 Pellet 100, with a nominal heat output of 100 kW and with the objective of producing useful heat for the purpose of room heating and water heating.

As per manufacturer information the heating boiler is designed for firing wood pellets (in accordance to ÖNORM M 7135 HP1 respectively DIN 51731 HP5).

The system in question consists basically of an outside fully insulated steel plate boiler with built-in tubular heat exchanger and integrated pellet burner.

The automatic fuel feeding takes place by a pneumatic system and a pellet integral fuel hopper.

The pellet burner, located in a vertically arranged fire tube, is fed with fuel via a filling tube with throw feed, welded on the side of the boiler case.

The fuel is over fed by a drop chute, which can be sealed off for back burning safety by a closing slide from the hopper and the pneumatic system.

The fuel ends on a moveable grate, ignition takes place by an automatic ignition device.

The combustion air is sucked in at the rear of the boiler by means of the exhaust gas fan into an air jacket, giving the division in primary and secondary air.

The air supply takes place primary through the rust and secondary above the firebed by several symmetrical splitted secondary air tubes, which are integrated in the combustion chamber.

The flue gas passes the flame tube upwards to a horizontal reversing chamber from where they reach the fly ash collecting area via a downwards draught chamber and this lead to vertically oriented heat exchanger tubes in a flue gas collecting box. Afterwards the flue gas is transported with the exhaust gas fan to the stack.

To optimize heat transfer and for cleaning the third pass of the heat exchanger tubes is equipped with automatically operated turbulators (efficiency optimization system WOS).

The cleaning of the first and second pass takes place manually with cleaning tools.

Within the boiler ash accumulates as rust ash below the grate and as fly ash in the area below the heat exchanger. The ash is discharged with ash removal screws into ash boxes with detachable cover situated behind the boiler insulation on the boiler front.

The difference between actual and desired boiler temperature controls within the prescribed limits of flue gas temperature the amounts of combustion air and fuel.

The regulation of the oxygen content in the flue gas takes place by means of a lambda probe via variation of fuel feeding. In this connection an indirect adaptation to the fuel qualities is performed.

The evaluation of the fire protection system of the back burning safety device installed in the boiler unit was made in a separate expertise by the IBS (Institute for Fire Protection Engineering and Research Ltd.) according to prTRVB H 118.

For test performance the needed pellets amount for combustion is weighed and manually filled in the pellets hopper.

In normal operation the input of pellets into the pellets hopper takes place with a pneumatic conveying system.

A sectional view of the pellets boiler unit of the type P4 Pellet 60 is given to the test report in enclosure 2.

2.2.1 Technical data of the tested boiler (as per manufacturer data)

2.2.1.1 Boiler

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Model:	pellets boiler
Type:	P4 Pellet 100
Serial number:	100.1087.U.20
Year of construction:	2010
Nominal heat output:	100 kW
Heat output range:	30 – 100 kW
Nominal fuel heat output:	109 kW
Allowable fuels:	wood pellets (in accordance with ÖNORM M 7135 HP1 and DIN 51731 HP5)
Max. allowable operating temperature:	80°C
Max. allowable operating pressure:	3 bar
Water content:	280 l
Boiler class:	3
Electrical connection:	230V; 50Hz; 16 A; 120 W

Main dimensions

Boiler type:	P4 Pellet 100
Boiler length:	1000 mm
Boiler width:	1235 mm
Boiler height:	1710 mm
Total length incl. exhaust gas fan:	1070 mm
Total width incl. suction cyclone:	2085 mm
Total height incl. suction cyclone:	1900 mm
Weight of the boiler:	1100 kg
Flue gas pipe connection:	d = 200 mm

2.2.1.2 Firing

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Design:	pellets firing with special retort
Type:	P4 Pellet 100
Year of construction:	2010
Air supply for combustion:	primary and secondary, divided by air dampers
Fuel feeding:	regulated by lambda probe control
Boiler control:	Lambdatronic P 3200

2.2.1.3 Heat exchanger, integrated in the boiler

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Design:	counter-current passed through heat exchanger with three passes

2.2.1.4 Appliances for emission collection

Exhaust gas fan

Manufacturer:	Moll motor
Design:	radial fan
Type:	R2E 210 – AB34
Speed:	2600 rpm
Power requirement:	120 W

2.2.1.5 Appliances for emission reduction

Efficiency optimization system (WOS):

Manufacturer:	Fröling Heizkessel- und Behälterbau GesmbH
Design:	automatically operated turbulators
Intended use:	for cleaning the third pass of the heat exchanger tubes and to discharge flue ash
Reduced pollutants:	dust

2.2.1.6 Data of emission source used at test rig (stack)

Design:	stainless steel
Connected units:	test rig 1, test stand 4, boiler type P4 Pellet 100
Number of stack drafts:	1
Stack height above ground:	10,1 m
Outlet diameter:	d = 0.35 m
Outlet sectional area:	A = 0.096 m ²

3. TEST OF GENERAL REQUIREMENTS

3.1 CONSTRUCTION REQUIREMENTS

For the subject pellets boiler type of the make Fröling, the P4 Pellet 100, an EC Declaration of Conformity of the boiler manufacturer to Machinery Directive 2006/42/EG is on hand of TÜV AUSTRIA SERVICES GMBH, in which the conformity in the characteristic as central heating boiler for solid fuels according to EN 303-5:1999 is declared with the regulations of EC Directives 2006/42/EC (Machinery Directive), 2006/95/EC (Low Voltage Directive) and 2004/108/EC (EMC Directive) in the following relevant references:

- EN ISO 12100-1:2004
- EN 60335-1:2007
- EN 61000-6-2:2005 and EN 61000-6:2007

A copy of the production documents, showing the relevant drawings, the production controls, the execution of welding work, the welding seams and welding fillers, the wall thicknesses and the safety designs, was submitted to TÜV AUSTRIA SERVICES GMBH and is kept for perusal at the test centre Thalheim/Wels.

The evaluation of the fire protection system of the back burning safety device installed in the boiler unit was made in a separate expertise by the IBS (Institute for Fire Protection Engineering and Research Ltd.) according to prTRVB H 118.

On examination of the production documents submitted to TÜV AUSTRIA SERVICES GMBH no deviation from the construction requirements of ÖNORM EN 303-5:1999 was found in the construction.

The essential construction requirements of ÖNORM EN 303-5:1999 for the subject boiler type are described in extracts below.

3.1.1 General requirements

Boilers shall be fire-resistant and safe to operate. They shall be made of non-combustible materials, resistant to deformation and designed so that

- they shall withstand the stresses arising during normal operation;
- the heat carrier (water) shall not become heated to a dangerous extent;
- gases shall not leak from the boiler in dangerous quantities into the place of installation;
- when the boiler is operated correctly flames do not flare out and embers do not fall out;
- dangerous accumulations of combustible gases in the combustion chamber and in the flues are prevented;

Component parts of covers, operating controls, safety devices and electrical accessories shall be arranged in such a way that their surface temperature, under steady state conditions, do not exceed those specified either by the manufacturer or in the component part standards.

The materials for the parts subject to pressure shall be in accordance with generally accepted technical requirements. They shall be suitable for the purpose and treatment intended.

The mechanical and physical properties as well as the chemical composition of the materials shall be guaranteed by the relevant material producer.

In addition the range of the draught stated by the manufacturer in the technical documentation shall be observed.

Correct and risk-free operation of the system should be described in the operating instructions, and the risks resulting from incorrect operation should be noted by the manufacturer.

In the case of conventional and appropriate use the tested pellets boiler type P4 Pellet 100 is conform to the general requirements of the ÖNORM EN 303-5:1999 mentioned in point 3.1.1 of this report.

3.1.2 Production documentation

3.1.2.1 Drawings

In the documentation handed over to TÜV AUSTRIA SERVICES GMBH are specified:

- the materials used;
- the welding processes, the seam type and the welding fillers;
- the maximal allowable operating temperature in °C;
- the maximal allowable operating pressure in bar;
- the test pressure in bar;
- the nominal heat output in kW in accordance with the fuel

3.1.2.2 Production controls

A Quality Manual shall be compiled on the inspections and tests necessary during the manufacturing process.

Before the start of production and in the serial production the manufacturer has to prove, that according to his Quality Assurance System, the execution of construction work corresponds to the construction regulations, the specified materials has been used in the manufacturing, the welding has been done correctly and all needed tests were performed successfully.

The boiler manufacturer has established a Quality Manual and a quality management system, available for the scopes design, production, sales and service of biomass heating systems, which are certified according to EN ISO 9001:2008 by TÜV Cert-certification centre of TÜV Austria.

3.1.3 Heating boilers made of steel and non-ferrous materials

At the time of testing, the boiler manufacturer had a certificate from TÜV AUSTRIA, no. A/027/07 of 06/12/2007, to show that the requirements of § 14 Kesselgesetz (Austrian Federal Law Gazette No. 211/1992) have been met.

3.1.3.1 Execution of welding work

Boiler manufacturers who carry out welding work shall meet the requirements of EN 287-1 and EN 287-2.

Therefore shall be used:

- only welders who are qualified in the welding of the materials to be processed may be used
- equipment shall be available to allow defect free welding to be carried out
- supervision of the welding shall be carried out by staff qualified in welding (at least 1 supervisor shall be so qualified, in this case: 1 welding technologist and 2 welding foremen)

3.1.3.2 Welding seams and welding fillers

The used materials shall be suitable for welding.

In executing the welding seams the adherence of the requirements of the ÖNORM EN 303-5:1999 has to be observed and be ensured by appropriate controls.

Welding fillers shall be suitable for the material being used.

The used materials are suitable for welding and do not require additional heat treatment after welding.

The used welding fillers allow a welding connection which matches to the base material.

At the subject boiler type the underlying terms are in accordance with EN 22553, the reference numbers of welding processes are in accordance with ISO 857 respectively EN 24063.

3.1.3.3 Parts of steel subject to pressure

The type of steels listed in table 1 of the ÖNORM EN 303-5:1999 are used.

The specifications of the materials used in the subject boiler type are documented by works certificates (in accordance with EN 10204, with the exception of small parts) by the boiler manufacturer.

3.1.3.4 Minimum wall thicknesses

The specified requirements for minimum wall thickness listed in ÖNORM EN 303-5:1999, table 3, point 4.1.3.4. are met by taking account of

- the maximum allowable operating pressure,
- the nominal heat output and
- the material properties

On examination of the documents submitted to TÜV AUSTRIA SERVICES GMBH with regard to carrying out welding, weld seams and welding additives, pressure-stressed parts and minimum wall thicknesses, as described in 3.1.2 and 3.1.3, the tested pellets boiler type P4 Pellet 100 met the requirements of ÖNORM EN 303-5:1999.

3.1.4 Safety and design requirements

3.1.4.1 Venting of the water sections and gas flue passages

The boiler and its components shall be designed in such a way that their respective water sections can be fully vented.

The boiler shall be so designed that under normal operation in accordance with the manufacturer's instructions no undue boiling noises occur.

At the subject pellets boiler type a 1-inch-connection at the highest place of the heat exchanger tube is installed for water-section venting.

The boiler installation shall carry out increasing towards the flow connection. In accordance to the manufacturer's specification the venting of the water section shall be provided by customer with a venting appliance.

The correct installation of the heating boiler (increasing towards the flow connection), the preparation of a corresponding connection in the flow needed by customer and the venting procedure has to be included in the installation instructions and in the operation instructions.

The combustion chamber and the flue gas passages shall be designed in such a way that no dangerous accumulation of combustible gases is possible (here: realized by exhaust fan with adequate run-down times after boiler shutdown and with O₂-control).

3.1.4.2 Cleaning of heating surfaces

The heating surfaces shall be accessible from the flue gas side for inspection and cleaning with chemical agents and brushes. A sufficient number and appropriate arrangement of cleaning openings shall be provided. If special tools (for example special brushes) are required for cleaning and maintenance of the boiler these should be supplied.

At the pellets boiler type P4 Pellet 100 the cleaning of the first two passes takes place mechanical with brushes supplied by the manufacturer. The automatic cleaning of the third pass is done by the integrated WOS-system.

Further at the top side of the boiler two cleaning cover ports are situated behind the boiler insulation for the annual maintenance at boiler shutdown.

In accordance to the manufacturer's specification the special tools for cleaning and maintenance are included.

3.1.4.3 Inspection of the flames

A facility shall be provided which allows inspection of the flame or fire bed. If this facility is a door, then hazard-free inspection shall be possible (here: sheet with metallised film, set on edge, situated in the zone of filling duct/downcomer of the stoker screw conveyor with the possibility of fire-bed inspection).

3.1.4.4 Water tightness

Holes for screws and similar components which are used for the attachment of removable parts shall not enter into spaces through which water flows. This does not apply to pockets for measuring or control and safety equipment.

3.1.4.5 Replacement parts

Replacement and spare parts (e.g. inserts, shaped firebricks, WOS etc.) shall be designed, produced or identified in such a way that they can only be installed according to the manufacturer's instructions.

3.1.4.6 Water side connections

Adaptor nipples shall comply with the Standards ISO 7-1 ISO 7-1, ISO 7-2, ISO 228-1 and ISO 228-2 and flange connections shall comply with ISO 7005-1, ISO 7005-2 and ISO 7005-3. The arrangement of the connections shall be such that they are easily accessible and the function of each respective connection can be adequately fulfilled. There shall be sufficient space around the connection to allow the installation of the connecting pipes (flanges, bolts) with necessary tools.

Threaded pipe connections above DN 50 should not be recommended. Threaded pipe connections with nominal diameters above DN 80 are not permissible. If connections are fitted with flanges, the mating flanges and seals shall also be supplied except standardized flanges are available.

The boiler shall have at least one connection for filling and emptying. This connection may be common. The size of the connection shall be as minimum

- G ¾ for nominal heat outputs over 70 kW.

It is possible to provide these connections outside the boiler if satisfactory filling and emptying of the boiler can be assured.

At the pellets boiler type P4 Pellet 100 are installed:

- Feed and return: 1 connection each, with 2 inch in each case
- Filling/emptying: 1 connection with 1 inch

3.1.4.7 Connections for control and indicating equipment, and safety thermostat

Every boiler shall be equipped with at least one connection for an immersion pocket for temperature control, safety-temperature limiter and thermometer. Its minimum nominal diameter shall be G ½.

Deviations are allowed, provided that the control devices are supplied with the boiler, and that they can not be substituted by other components.

The position of the connections shall be chosen in such a way that the temperature of the boiler water is recorded with sufficient accuracy.

Where additional connections for safety devices such as a pressure detector, monometer, low water cut-out device or a safety valve are provided for, their size, especially the safety valve is to be determined according to the output and the range of application of the boiler.

At the water-side of the pellets boiler type P4 Pellet 100 two immersion pocket sockets, with a nominal diameter ½ inch each, are installed.

3.1.4.8 Thermal insulation

All boilers shall be fitted with thermal insulation. The thermal insulation shall withstand normal thermal and mechanical stresses. It shall be made of non-combustible material and shall not give off fumes during normal running.

All boilers shall be fitted with thermal insulation. The thermal insulation shall withstand normal thermal and mechanical stresses. It shall be made of non-combustible material and shall not give off fumes during normal running (here: aluminium-coated multi-disc-insulating mat, size 60 mm).

3.1.4.9 Water side resistance of the boiler

The water side resistance was determined for those flows which correspond to the nominal heat output with two temperature differences of 10 K and 20 K between the flow and return connections of the boiler. The results are shown under 5.3 in the test report.

3.1.4.10 Temperature control and limiting devices

The control and safety devices described in the sections below and the appropriate installation options shall be provided for each boiler, depending on the type of firing system and the type of protection provided for the installations in which the boiler is to be fitted. The equipment required in each case shall be supplied by the boiler manufacturer's along with the boiler; if not precise specifications shall be given in the installation instructions, in particular the limit values and time constants for safety temperature limiter.

Temperature control and limiting devices for closed vented system

When used in thermostatically protected heating installations the firing system shall either rapidly or partly disconnectable, and/or the heat or residual heat output not absorbed by the heating system shall be dissipated reliably using a safety heat exchanger or equivalent devices.

At the subject pellets boiler type P4 Pellet 100 a rapidly disconnectable firing system is installed, which equipment consists of a temperature controller and a safety temperature limiter in accordance to ÖNORM EN 303-5:1999.

3.1.4.11 Combustion chamber

The combustion chamber shall be designed in such a way that the fuel moves freely and the duration of the combustion period is assured.

In the context of the type test the fulfilment of the requirement was proven.

3.1.4.12 Ash chamber

The capacity of the ash chamber shall be adequate for a combustion period of at least 12 hours using the stipulated fuel and at nominal heat output – taking into account the unobstructed flow of air under the grate. In the course of the type test, it was established that this requirement is met.

If - as in the present case - facilities are installed for an automatic ash and slag removal, the requirement is met.

3.1.4.13 Stoking devices

It is assumed that automatic stoking systems shall be designed with a safety device to prevent back-burning into the feeder or metering device or creating a blow-back.

In the subject case the fuel feeding takes place over fed diagonally by a drop chute, which can be sealed off for back burning safety by a closing slide from the hopper and the pneumatic system.

The evaluation of the fire protection system of the back burning safety device installed in the boiler unit was made in a separate expertise by the IBS (Institute for Fire Protection Engineering and Research Ltd.) according to prTRVB H 118.

3.1.4.14 Heating boiler accessories

If the boiler is factory equipped with additional fittings and if they need to be serviced to ensure the correct operation and safety of the boiler, the design should not require extensive dismantling work.

3.1.4.15 Electrical safety

The requirements of electrical safety is to be conducted on the basis of EN 60335-1.

(1) General specifications

- type of the boiler protection (in accordance with EN 60529);
- specifications concerning electrical components (e.g. switches, relays).

(2) Certificates of conformity:

Detailed certification is to be supplied by the equipment manufacturer for:

- heating;
- operation of equipment with electrical heating elements under overload condition;
- interference suppression;
- thermal endurance, resistance to creeping.

A summary of a technical report of TÜV SÜD Rail GmbH , No. FG 81883 T from 10.08.2007, in which the agreement with the requirements of EN 60335-1:06 and EN 60335-2-102:06 is attested, is available for inspection on TÜV AUSTRIA SERVICES GMBH.

An EMC-compatibility test of the control model used in the pellets boiler type (control model type Lambdatronic P 3200) was hand on at TÜV AUSTRIA SERVICES GMBH in the context of type test.

3.1.4.16 Surface temperatures

In the context of the nominal heat output test the surface temperatures of the boiler and the boiler parts shall not exceed the room temperature by more than the following temperatures in accordance to point 5.12 of ÖNORM EN 303-5:1999:

- mean surface temperature of boiler doors and cleaning port covers on the operator side: 100 K
- surface temperature on the outside of the boiler bottom: 65 K
- surface temperature of operating levers and all parts which shall be touched by hand during operation of the heating boiler:
 - 35 K for metals and similar materials
 - 45 K for porcelain and similar materials
 - 60 K for plastic and similar materials

In the case of the boiler type in question, the inner boiler doors at the front are shielded from the possibility of direct contact by a second, fully covering insulating door.

In the context of type test and the perusal of documentation the tested pellets boiler type P4 Pellet 100 showed in case of conventional and appropriate use no deviations to the safety and design requirements of the ÖNORM EN 303-5:1999, mentioned in point 3.1.4 of the report.

3.2 PRESSURE TESTS

Before the start of production, boilers shall be subjected to the rating test. During production the construction and water pressure tests shall be carried out.

At this all boilers and their parts shall be subjected to a hydraulic or pneumatic pressure test at the production site of the manufacturer. No leakage shall occur.

3.2.1 Tests to be carried out before production

The type test pressure is $2 \times p_1$ using hydraulic pressure (p_1 is the maximum permissible operating pressure, here: $p_1 = 3$ bar).

The test period shall be at least 10 minutes and if it is to apply to a type range of boilers, the test shall be carried out on at least 3 boiler sizes (smallest, medium and largest size). No leakage or noticeable permanent deformation shall occur during the rating test.

A record shall be made of the test giving the following details:

- exact description of the boiler tested stating the drawing number;
- test pressure in bar and duration of the test;
- test result;
- place and date of the test including the names of persons carrying out the test. The test shall be signed by, as a minimum the works tester responsible and one witness.

An adequate record of a rating test of the pellets boiler type P4 Pellet 100 is on hand of the TÜV AUSTRIA SERVICES GMBH (cold water pressure test, test pressure $2 \times p_1 = 6$ bar, test duration 15 minutes).

3.2.2 Test during production

During production the test pressure shall be according to ÖNORM EN 303-5:1999 at a minimum of 4 bar at the pellets boiler type P4 Pellet 100.

The tests have to be arranged by the boiler manufacturer.

The requirements of ÖNORM EN 303-5:1999, mentioned in the following points 3.3, 3.4.1 and 3.4.2, are an indication from TÜV AUSTRIA SERVICES GMBH to the boiler manufacturer, which specifications have to be enclosed in the technical documents being supplied with the boiler.

3.3 DESIGNATION

Each heating boiler shall have a data plate. The boiler data plate shall be written in the language of the boiler's country of destination and be affixed in an accessible spot.

3.3.1 Information on the boiler plate

- a) name and company domicile of the manufacturer and, where available, the manufacturer's symbol;
- b) trade designation, type under which the boiler is marketed;
- c) production number and year of construction (coding is permissible at the manufacturer's discretion);
- d) nominal heat output and heat output range in kW for each type of fuel;
- e) boiler class;
- f) maximal allowable operating pressure in bar;
- g) maximal allowable operating temperature in °C;
- h) water content in l;
- i) electrical connection (V, Hz, A) and wattage in W.

3.3.2 Data plate requirements

The material and labelling used for the plate shall be durable. The labelling shall be abrasion-proof. Under normal operating conditions the plate shall not discolour so as to make its information difficult to read.

3.4 TECHNICAL DOCUMENTATION, SUPPLIED WITH THE BOILER

For each boiler the documents listed below shall be available, preferably in the language of the boiler's country of destination; the documents specified under point 3.4 shall be enclosed with every boiler and they have to be amended if necessary.

The pellets boiler type P4 Pellet 100 showed exhaust gas temperatures below 160 K above room temperature in the context of the type tests performed by TÜV AUSTRIA SERVICES GMBH at nominal heat output (see point 5.1.1).

Therefore the boiler manufacturer shall make recommendations in the installation instructions regarding the flue installation in order to ensure sufficient draught and to prevent sooting up of the chimney and condensation.

Furthermore the range of the draught in accordance to the design shall be specified, and the correct and safe operation of the unit and information about the risks caused by improper operation has to be noted in the operating instructions.

The correct installation of the heating boiler (increasing towards the flow connection), the preparation of a corresponding connection in the flow needed by customer and the venting procedure has to be included in the installation instructions and in the operation instructions.

A copy of the technical information (operating instructions and installation instructions) was hand over to TÜV AUSTRIA SERVICES GMBH in the context of the tests and can be looked into in the test centre Thalheim/Wels.

The technical documentation being enclosed with the heating boiler shall contain the indications mentioned in point 3.4 and has to be adequately updated.

Other documents (brochures, etc.) shall not contain any information that is in contradiction with those of the technical information, installation instructions and operating instructions.

3.4.1 Technical information and installation instructions

In addition to the information listed under 3.4, these documents shall contain at least the following indications:

- necessary draught in mbar;
- water content in l;
- exhaust gas temperature at nominal heat output and minimum heat output in °C;
- exhaust mass flow nominal heat output and minimum heat output in kg/s;
- flue pipe diameter in mm;
- water-side resistance in mbar;
- nominal heat output and heat output range for each type of fuel in kW;
- boiler class;
- setting range for the temperature controller in °C;
- minimal return temperature at boiler return tapping in °C;
- fuel type and water content as well as fuel size;
- necessary accumulator storage in litres if $Q_{\min} > 0,3 Q_N$;
- auxiliary power requirement in W;
- needed cold water temperature and pressure for safety heat exchanger in bar;
- electrical connections including appliance- and main-switch-off.

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The installation instructions shall contain information concerning:

- the on-site assembly of the boiler, and if necessary the required pressure test;
- the installation;
- the necessary arrangements on site including information on the construction of the exhaust system
- the commissioning, with information on the boiler output to be set in the output range;
- instructions on the location and fitting of the sensors for the control, display and safety equipment.

It is also generally necessary to indicate the standards and regulations which have to be observed for the safety equipment in the system.

3.4.2 Operating instructions

The operating instructions of the subject automatically feeding boiler type shall contain references to:

- the operation of the boiler, stoking and opening doors without risk;
- cleaning and cleaning intervals, including the equipment required for the cleaning operations;
- measures to be taken in the event of malfunction;
- the behaviour in the case of malfunction;
- the reasons for recommending a regular, competent maintenance service and the necessary maintenance intervals;
- the type of fuel and water content and the fuel size;

4. TEST OF THE BOILER PERFORMANCE REQUIREMENTS

4.1 BOILER PERFORMANCE TEST

4.1.1 Choice and condition of the tested boiler

Fittings and accessories supplied by the manufacturer were installed and used correctly at the tested boiler. The operating and installation instructions were considered.

The condition and the equipment of the boiler to be tested were conforming to the normal supply specification in accordance with the manufacturer's instruction and the documents provided to TÜV AUSTRIA SERVICES GMBH.

Additional thermal insulation to parts in contact with water, products of combustion and fire were not used.

4.1.2 Setting up the test rig

The boiler performance test was carried out at the test rig of Fröling Heizkessel- und Behälterbau GesmbH in Grieskirchen. The test rig and the flue gas measuring section corresponded with the requirements of ÖNORM EN 303-5:1999.

The used measuring instruments and the measuring methods corresponded with the requirements of ÖNORM EN 303-5:1999.

The useful heat output transmitted to the water was determined using a calibrated heat meter, taking measurements of the flow of the water circulating in the boiler circuit (flow) and its temperature rise. The determination of the boiler efficiency of the biomass heating system was calculated using the formalism of the direct method expressed in ÖNORM EN 303-5:1999.

4.1.3 Measured quantities

One-off measurement:

- water content of the fuel;
- fuel mass added;
- combustion period;
- surface temperatures (at nominal heat output in a typical operating condition in accordance with ÖNORM EN 303-5:1999)
- water side resistance
- auxiliary power consumption in sleeping operation, at ignition process (electrical work) and auxiliary power consumption of the key consumers (fan motor, motor for cleaning of heating surfaces and to discharge flue ash, fuel discharge (suction device), stoker screw conveyor, back-burning damper motor)

Continuous measurement:

- heat output;
- flow temperature;
- return temperature;
- flow;
- ambient temperature;
- exhaust temperature;
- oxygen content (O₂);
- carbon monoxide content (CO);
- content of organic gaseous substances (OGC, shown as organically bound carbon);
- nitrogen oxides content (sum of NO and NO₂, shown as NO₂);
- auxiliary power consumption of the boiler unit;
- draught (static pressure in the flue gas pipe)

Discontinuous (intermittent) measurement:

- dust content

4.1.4 General test conditions

To determine the heat output, boiler efficiency, combustion period, composition of the flue gas, flue gas temperature, draught and emission properties, the boiler was operated throughout the tests within the heat output range specified by the boiler manufacturer.

The boiler heat output was the average of the output recorded during the test period.

At nominal heat output the boiler was operated in such a way that continuous running was possible without thermostat cut-off (boiler temperature control).

The minimum heat output was regulated by a control device.

The boiler was brought to operating temperature before the start of measurements, the draught was adjusted in accordance with the manufacturer's instruction and the boiler was operated during the test in accordance with the manufacturer instruction.

The test duration and thus also the combustion period duration were both at nominal heat output and at minimum heat output at least 6 hours.

The continuously registering measuring instruments for the determination of pollutant concentrations of the flue gas were taken at the test rig the day before the test.

The ambient temperature values were between 15°C and 30°C.

During tests at nominal heat output it was made certain that the mean value of flow temperature lay between 70°C and 90°C, whereby the mean temperature difference lay between flow and return between 10 K and 25 K.

During tests at nominal heat output the following temperature criteria were maintained furthermore:

$$\frac{t_V + t_A}{2} - t_L \geq 40,0K$$

Where:

t_V flow temperature in °C
 t_A return temperature in °C
 t_L ambient temperature in °C

4.1.5 Determination of the boiler efficiency

The efficiency of the biomass heating system was determined according to the formalism of the direct method shown in ÖNORM EN 303-5:1999 and related on the basis of the net calorific value H_u of the fuel being used.

During the test duration the boiler heat output was determined as average of the recorded values of the output.

The determination of the fuel mass fed to the biomass heating system took place via weighing with a calibrated top-pan balance (owner: TÜV AUSTRIA SERVICES GMBH) of the type Mettler PM 4600, maximum weight 4100 g, resolution 0.1 g.

Procedure for determination of fuel mass, added in the test period:

For this purpose in the lower zone of the pellets integrated fuel hopper, installed at the boiler unit, was fixed a mark before test start.

At test start and at test end the fuel filling height was pulled off at an area of 0.042 m² on the mark. The batchwise added amounts of fuel has been weighed by the balance mentioned above.

The useful heat output transmitted to the water was determined by a calibrated heat meter by measuring the flow of the water circulating in the boiler circuit and its temperature rise, whereby calibrated temperature sensors were installed in the flow and the return.

Technical data of the heat meter including calculation unit

Heat meter including calculation unit:

Manufacturer: Hydrometer
Type: Ultra SII 773
Serial number: 38077544
Year of construction: 2010
Flow: qi: 0.1 m³/h, qp: 10 m³/h, qs: 20 m³/h
Location of flow measuring system: return
Temperature measurements: Pt 100 (in flow and return)

Calculation of boiler efficiency

$$Q_B = \frac{m_B \cdot H_u}{3600} \qquad \eta_K = \frac{Q}{Q_B} \cdot 100$$

Q.....	heat output, the useful heat to water delivered by a boiler per time	in kW
Q _B	heat input, the amount of heat in time which is supplied to the furnace of the heating boiler by the fuel related to its net calorific value H _u .	in kW
H _u	net calorific value of the test fuel, as fired basis	in kJ/kg
η _K	boiler efficiency, ratio of the delivered useful heat output to the heat input	in %
m _B	fuel mass added to the heating boiler in the test period	in kg

At the subject type test the estimated measurement uncertainty of the total procedure for the determination of the boiler efficiency was ± 2 per cent.

4.1.6 Determination of exhaust gas loss (loss through sensible heat of the products of combustion)

The exhaust loss of the biomass heating system was calculated by the formalism mentioned below in accordance to the BGBl. II No 331/1997 (331. Federal Law Gazette of the Minister of Economic Affairs 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):

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

t _A	exhaust gas temperature °C (measured on the measuring point after flue gas exit of the boiler)
t _L	ambient temperature in °C
O ₂	dry oxygen content of the flue gas in % of vol.
A ₂	0.6650 for biomass with the test fuel wood pellets (water content of the fuel: 7.1 %)
B.....	0.0103 for biomass with the test fuel wood pellets (water content of the fuel: 7.1 %)

The input data used for the calculation of the exhaust gas loss at the measuring point after flue gas exit of the boiler are mentioned in point 5.1.1.

At the subject test the estimated measurement uncertainty of the total procedure for the determination of the exhaust gas loss was ± 0.4 per cent.

4.1.7 Determination of the emission values

The average O₂, CO, OGC and NO_x contents are determined over the entire test period (test duration at nominal heat output and test duration at minimum heat output at least each 6 hours).

The emission values for CO, NO_x and OGC has been determined both as half-hour values and as average value over the entire test period (at least 6 hours at nominal heat output and 6 hours at minimum heat output, referred to a dry flue gas basis at 0°C, 1013 hPa respectively to the energy content of the test fuel).

To determine the dust content the test period was divided into 6 equal time sections and the suction time per filter was limited to 30 minutes.

The average dust content was determined from the 6 half-hours values.

The volume of combustion gas was calculated by means of combustion gas calculation using the DIN 4702 on the basis of the chemical elementary analysis of the test fuel and the amount of fuel fired in the test period.

The velocity of the flue gas at the measurement point used to determine dust emissions was calculated from the volume of combustion gas, taking into account of cross section of the duct, pressure, temperature and moisture content of the flue gas.

For the calculation of the mean value of the emissions of O₂, CO, OGC and NO_x the measured concentrations have to be weighted by the flue gas volume.

In accordance to ÖNORM EN 303-5:1999 the acceptable approximation for the calculation of the mean value – the calculation of the mean value of the period independent of the volume stream of the flue gas – was used.

The part of organic gas parts was determined as organically bound carbon (OGC) in dry flue gas. The determination of the part of organic gas parts (OGC) was performed without splitting the individual components with a flame ionization detector (FID) for which calibration propane gas was used.

The sum of nitrogen oxides (NO_x), measured as sum of nitrogen monoxide (NO) and nitrogen dioxide (NO₂), is calculated and shown as nitrogen dioxide (NO₂).

4.1.8 Surface temperatures

For the determination of the mean surface temperature at nominal heat output the boiler surface of the pellets boiler type P4 Pellet 100 was divided in 14 incremental areas, whereby a total of 77 measuring points were regarded.

Under the same conditions the critical surface temperatures (e.g. boiler doors, operating levers etc.) and the surface temperature on the outside of the boiler bottom were measured at nominal heat output.

4.2 DETERMINATION OF THE WATER SIDE RESISTANCE

Within the type test the water side resistance was determined for those flows which correspond to the nominal heat output with two temperature differences of $\Delta t = 10$ K and $\Delta t = 20$ K between the flow and return connection of the boiler.

4.3 TEST FUEL

The tests were performed with a test fuel of commercial quality mentioned below. The supply of the test fuel took place via the boiler manufacturer.

Test fuel: wood pellets, company Sturmberger, Fire Stixx, d = 6 mm, water content w = 7.1 % (loose)

4.3.1 Fuel analysis

During the test period samples of the test fuel were taken by Mr. Schrögendorfer, TÜV AUSTRIA SERVICES GMBH.

The determination of the water content of the fuel samples took place via drying process in a drying oven in accordance to DIN 51718 and ÖNORM CEN/TS 14774-1, PN, part 1, in the test centre Thalheim/Wels of the TÜV AUSTRIA SERVICES GMBH.

The elementary analysis and the determination of the net calorific value of the fuel samples were performed in the laboratories of TÜV AUSTRIA SERVICES GMBH on the basis of DIN 51732 and DIN 51900.

The results of the fuel analysis carried out by TÜV AUSTRIA SERVICES GMBH on the test fuels burnt during the measuring periods are shown below.

The analysis results of elementary analysis and ash content are related to dry substance and the analysis results of net calorific value are related to raw condition.

	<u>fuel wood pellets</u>
Sampling date:	19/10/2010 and 20/10/2010
Net calorific value (H _u)	17270 kJ/kg
Water content of the test fuel (w):	7.1 % d. M.
Carbon content of the test fuel (C):	50.9 % d. M.
Hydrogen content of the test fuel (H):	6.2 % d. M.
Oxygen content of the test fuel (O):	42.5 % d. M.
Nitrogen content of the test fuel (N):	< 0.1 % d. M.
Ash content (815°C):	0.26 % d. M.

4.4 MEASUREMENT INSTRUMENTS AND METHODS

4.4.1 Flue gas boundary conditions

4.4.1.1 Flue gas volume and flue gas velocity

The volume of combustion gas was calculated by means of combustion gas calculation using DIN 4702 on the basis of the chemical elementary analysis of the test fuel and the amount of fuel fired in the test period. The velocity of the flue gas at the measurement point used to determine dust emissions was calculated from the volume of combustion gas, taking into account of cross section of the duct, pressure, temperature and moisture content of the flue gas.

4.4.1.2 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
Standard:	VDI 2066, Part 1
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, but at least ± 0,01 hPa

4.4.1.3 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

4.4.1.4 Flue gas temperature

Measuring method:	thermoelectric
Measurement sensor:	thermoelements Fe-Cu-Ni
Measuring device:	digital display instrument
Manufacturer:	Mesa Electronic
Model:	A009.411.40.40
Uncertainty:	Range ≤ 150°C: ± 2°C Range > 150°C: ± 1.5 % of measured value

4.4.1.5 Ambient air and combustion air temperature

Instrument: portable electronic measuring instrument
 Sensor: Pt 100
 Manufacturer: Testo
 Type: Testo 925
 Uncertainty: $\pm 1^\circ\text{C}$

4.4.1.6 Water content in the flue gas (flue gas humidity)

The flue gas humidity was calculated taking into account the elementary analysis of the test fuels and the continuously recorded measured flue gas composition.

4.4.1.7 Flue gas density

The flue gas density was calculated taking into account the flue gas proportions of O₂, CO₂, N₂, CO, flue gas humidity, flue gas temperature and the pressure conditions in the duct.

4.4.2 Gaseous and vapourous emissions

The procedure for the determination of the water content in the flue gas is described in point 4.4.1.6.

4.4.2.1 Continuously recorded measuring instruments

O₂, CO and CO₂ concentration

Basis for procedure: ÖNORM EN 14789, ÖNORM EN 15058, ISO 12039
 Comment on CO₂: The measurements were carried out with a continuous NDIR measuring device.
 Measuring device: Combined O₂, CO, CO₂ and SO₂ analyser
 Manufacturer: Rosemount
 Model: NGA 2000 MLT
 Inventory number: UW2-026/2

Measurement ranges	O ₂ [% of vol.]	CO [mg/m ³]	CO ₂ [% of vol.]
Measuring principle	Paramagnetism	NDIR	NDIR
Measurement range used	0 – 25	0 – 1000	0 – 20
Uncertainty	± 0.4 % of vol.	± 1 % of range value	± 0.4 % of vol.

CO – range up to 10 vol.-%

Manufacturer: Maihak
 Model: Unor 6 N
 Inventory number: UW2-119
 Measurement method: Non-dispersive infrared spectroscopy
 Measurement ranges: 0-10 Vol-% (0 – 100000 ppm)
 Uncertainty: Range > 1000 ppm: ± 2 % of measured value

NO_x

Manufacturer: Rosemount
 Model: NGA 2000 CLD
 Inventory number: UW2-026/2
 Measurement method: Chemiluminescence
 Measurement range used: 0-1000 ppm
 Uncertainty: ± 5 % of measured value, but at least ± 5 ppm

Sampling line 4 (situated downstream of gas conditioning) for determination of the concentrations of O₂, CO, CO₂ and NO_x:

Material/heating: Teflon, unheated
 Length: approx. 3 m
 Inside diameter: 4 mm
 Outside diameter: 6 mm

4.4.2.3 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

4.4.2.4 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 company Messer Austria mentioned below.

Parameter	Test gas concentration as per certificate of analysis	Manufacturer	Tolerance of test gas analysis in accordance to the manufacturer's specification
CO	718 mg/m ³ CO	Messer Austria	± 2 % of test gas concentration
CO ₂	14.7 % of vol. CO ₂	Messer Austria	± 2 % of test gas concentration
NO _x	677 ppm NO	Messer Austria	± 2 % of test gas concentration
C	90.8 ppm C ₃ H ₈	Messer Austria	± 2 % of test gas concentration

The adjustment of the reference point of the O₂-analyzer was taken by ambient air.

The adjustment of the zero points of the gas analysis instruments was taken by nitrogen of the quality 5.0.

After finishing the test periods the zero and reference points of the gas analysis instruments has been checked by feeding the reference materials mentioned above.

4.4.2.5 Check of the instrument characteristic

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

4.4.2.6 Response time of the overall measuring apparatus

The response time (t₉₀ – time) of all continuously recorded measured flue gas components was below 120 s.

4.4.3 Particulate emissions

4.4.3.1 Dust

Sampling probe:	titanium, heated by flue gas
Position of the filter holder:	external of duct, heated on approx. 100°C
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 silica-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 was less than one week
Uncertainty:	± 5 % of the measured value, but at least ± 1.5 mg/m ³
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 (in the exsiccator)
Leakage test of the apparatus for dust measurement:	the leakage test took place via applying a vacuum before the performance of the single measurements.

Gas volume meter for determining the partial gas flow extracted during the dust measurements:

Manufacturer:	Elster
Type:	dry design, BK G2.5
Uncertainty volume:	± 2 % of the measured value

Analytical balance:

Manufacturer:	Mettler Toledo
Type:	XS 205 dual range
Graduation:	0.01 mg
Weighing range:	0 – 81 g

4.4.4 Surface temperatures

Manufacturer:	Testo
Type:	Instrument: KM 330
	Sensor: SK 21M
Uncertainty:	± 1°C

4.4.5 Water side resistance

Measuring device:	Differential pressure meter
Manufacturer:	CBI and Special Instruments
Serial no.:	S 501 0806 60404
Measurement range:	CBI: - 5 to + 205 hPa, SI: 0-200 hPa
Uncertainty:	± 5% of the measured value

4.4.6 Auxiliary power consumption

For the determination of the auxiliary power consumption following measuring instruments are used:

Manufacturer: Carlo Gavazzi
Type: three phase power meter, type EM24 DIN, AV93XO2P
Uncertainty: $\pm 2\%$ of the measured value, but at least $\pm 5\%$

4.5 SAMPLING POINTS FOR THE DETERMINATION OF THE EMISSION VALUES

The measurements took place at the measuring points described below.

Measuring point after the flue gas exit of the boiler for determination of the flue gas temperature

The measuring point was situated directly after the flue exit of the boiler in the vertical flue gas duct.

Measuring point for the determination of the gaseous pollutants

The sampling took place from the upwards inclined flue gas duct between the flue gas exit of the boiler and the inlet of the flue gas into the chimney.

Length of the straight inlet: 1.15 m
Length of the straight outlet: 0.85 m
Circular cross section: $d = 0.19$ m

Measuring point for the determination of dust

The probe for the determination of the dust concentration of the flue gases was situated 0.2 m after the measuring point for the determination of the gaseous pollutants from the upwards inclined flue gas duct between the flue gas exit of the boiler and the inlet of the flue gas into the stack.

Length of the straight inlet: 1.3 m
Length of the straight outlet: 0.65 m
Circular cross section: $d = 0.19$ m

4.5.1 Number of metering shafts and location of the measuring points in the measuring section

The sampling for the determination of the gaseous and particulate pollutants took place at one measuring point (in the middle of the duct) on basis of the small measuring section.

4.6 OPERATING CONDITIONS OF THE SYSTEM DURING THE MEASUREMENT PERIOD

The heating boiler of the type P4 Pellet 100, set up at the test rig of Fröling Heizkessel- und Behälterbau GesmbH, became fired at nominal heat output (full load) and at maximum 30 % of the heat output of the biomass heating system (minimum heat output in accordance to the manufacturer's instructions, partial load) with the test fuel mentioned below in the period of 18/10/2010 – 05/11/20110.

Test fuel: wood pellets, company Sturmberger, Fire Stixx, d = 6 mm, water content w = 7.1 % (loose)

The determination of the amount of heat input which was supplied to the furnace of the heating boiler by fuel was performed by weighing the supplied fuel mass and consideration the analysis data determined from the fuel analysis of the samples performed by TÜV AUSTRIA SERVICES GMBH.

Details about the general test conditions are mentioned in point 4.1.4 and details about the fuel being fired in the test period are mentioned in point 4.3 of the test report.

The useful heat output transmitted to the water was determined by a calibrated heat meter by measuring the flow of the water circulating in the boiler circuit and its temperature rise.

The operating conditions of the pellets boiler type during the measurements are shown below.

Diagrams of the continuous recorded operating data of the unit during the test period are given to the report in extracts in enclosure 4.

Operating conditions of the unit during the measurements – boiler type P4 Pellet 100, fuel wood pellets

Parameter	Nominal heat output	Minimum heat output
Date of measurements	19/10/2010	20/10/2010
Measuring time (from – to)	09:18-15:18	09:12-15:12
Test duration (hours)	6.0	6.0
Air temperature, external the test rig (C)	9	8
Boiler temperature (°C)	73.7	73.1
Feed (%)	34.2	8.7
Exhaust gas fan (%)	59	21
Flow (m ³ /h)	4226	1138
Flow temperature (°C)	76.3	74.2
Return temperature (°C)	55.8	56.1
Temperature difference flow-return (°C)	20.5	18.1
Heat output useful generated (kW)	99.43	23.67
Heat output in % of nominal heat output	99.4	23.7
Fuel mass added (kg)	131.908	31.587
Fuel mass fired per hour (kg/h)	21.98	5.26

5. TEST RESULTS

5.1 EMISSION BEHAVIOUR OF THE BIOMASS BOILER

All given pollutant emissions are calculated as mass of the components in relation to the energy content of the fuel in the dimension mg/MJ as mean values over the mentioned measuring periods.

They are related to the energy content of the fuel used in the furnace as well as related to a dry flue gas basis at 0°C, 1013 hPa.

Additionally the concentrations of the components related to a dry flue gas basis at 0°C, 1013 hPa at actual oxygen content and calculated on hypothetical oxygen contents of 10 % O₂, 11 % O₂ and 13 % O₂ are given as average values in the dimension mg/m³ over the mentioned measuring periods.

The measurement uncertainty of the used measurement instruments and the measurement methods are given in point 4 of the test report.

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

5.1.1 Flue gas boundary conditions

Pellets boiler type P4 Pellet 100, fuel wood pellets

Parameter	Nominal heat output	Minimum heat output
Date of measurements	19/10/2010	20/10/2010
Measuring time (from – to)	09:18-15:18	09:12-15:12
Test duration (hours)	6.0	6,0
Air pressure at the height of the sampling point (hPa)	972	967
Ambient air temperature (°C)	9	8
Combustion air temperature (°C)	20.1	19.5
Flue gas temperature at the measuring point after the flue gas exit of the boiler (°C)	116	86
Flue gas temperature at the measuring point dust (°C)	113	82
Static pressure in the flue gas pipe (hPa)	- 0.08	- 0.06
Oxygen concentration (% of vol.)	4.78	8.81
Carbon dioxide concentration (% of vol.)	15.3	11.5
Flue gas humidity (kg/m ³)	0.11	0.09
Specific volume of dry flue gas (m ³ /kg fuel)	5.72	7.61
Fuel mass fired per hour (kg/h)	21.98	5.26
Dry flue gas volume (m ³ /h)	126	40
Flue gas velocity at the measuring point dust (m/s)	2.1	0.6

5.1.2 Dust

Dust emission – pellets boiler type P4 Pellet 100 – nominal heat output, fuel wood pellets

Date of measurements: 19/10/2010
 Test period: 09:18-15:18
 Heat output useful generated: 99.43 kW

Measuring time from – to	Actual O ₂ -concentration % of vol.	Dust concentration related to				Dust emission mg/MJ
		actual O ₂ mg/m ³	10 % O ₂ mg/m ³	11 % O ₂ mg/m ³	13 % O ₂ mg/m ³	
09:18-09:51	4.7	35	24	21	17	12
10:18-10:48	4.8	39	26	24	19	13
11:18-11:48	4.7	37	25	23	18	12
12:18-12:48	4.8	39	26	24	19	13
13:18-13:58	4.8	36	24	22	18	12
14:18-14:48	4.8	38	26	23	19	13
Average	4.8	37	25	23	18	13

Dust emission – pellets boiler type P4 Pellet 100 – minimum heat output, fuel wood pellets

Date of measurements: 20/10/2010
 Test period: 09:12-15:12
 Heat output useful generated: 23.67 kW

Measuring time from – to	Actual O ₂ -concentration % of vol.	Dust concentration related to				Dust emission mg/MJ
		actual O ₂ mg/m ³	10 % O ₂ mg/m ³	11 % O ₂ mg/m ³	13 % O ₂ mg/m ³	
09:14-09:44	9.2	26	24	22	18	12
10:12-10:42	8.9	24	22	20	16	11
11:12-11:42	8.8	22	20	18	14	10
12:12-12:47	8.3	23	20	18	14	10
13:22-13:58	8.2	24	21	19	15	10
14:12-14:42	9.0	23	21	19	15	10
Average	8.7	24	21	19	15	10

5.1.3 Carbon monoxide (CO), nitrogen oxides (NO_x) and organic gaseous substances (OGC)

The results of the pollutant concentrations for CO, NO_x and OGC, determined for the operating conditions nominal heat output and minimum heat output in the measuring period, are mentioned below.

Here for the proof of the fulfilment of the requirements of the FAV for the mentioned pollutants the calculated half-hour average values per fuel and per operating condition are stated referred to a hypothetical oxygen contents of 13 % O₂.

Additionally in accordance with ÖNORM EN 303-5:1999 the average values of the pollutant concentrations are given over the entire test period of in each case 6 hours per operating condition.

The sum of nitrogen oxides (NO_x), measured as sum of nitrogen monoxide (NO) and nitrogen dioxide (NO₂), is calculated and shown as nitrogen dioxide (NO₂).

The determination of gaseous organic carbon substances (OGC) was performed without splitting the individual components with a flame ionisation detector (FID) for which calibration propane was used.

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

5.1.3.1 Half-hour average values pellets boiler type P4 Pellet 100 – carbon monoxide (CO)

CO-emission fuel wood pellets

Fuel wood pellets – nominal heat output			Fuel wood pellets – minimum heat output		
Date	Measuring time from-to	CO-concentration related to 13 % O ₂ of vol. mg/m ³	Date	Measuring time from-to	CO-concentration related to 13 % O ₂ of vol. mg/m ³
19/10/2010	09:18-09:48	8	20/10/2010	09:12-09:42	53
	09:48-10:18	7		09:42-10:12	50
	10:18-10:48	8		10:12-10:42	48
	10:48-11:18	7		10:42-11:12	45
	11:18-11:48	7		11:12-11:42	37
	11:48-12:18	7		11:42-12:12	36
	12:18-12:48	8		12:12-12:42	36
	12:48-13:18	9		12:42-13:12	40
	13:18-13:48	9		13:12-13:42	38
	13:48-14:18	9		13:42-14:12	40
	14:18-14:48	9		14:12-14:42	35
14:48-15:18	10	14:42-15:12	36		

5.1.3.2 Half-hour average values pellets boiler type P4 Pellet 100 – nitrogen oxides (NO_x)

The sum of nitrogen oxides (NO_x), measured as sum of nitrogen monoxide (NO) and nitrogen dioxide (NO₂), is calculated and shown as nitrogen dioxide (NO₂).

NO_x-emission fuel wood pellets

Fuel wood pellets – nominal heat output			Fuel wood pellets – minimum heat output		
Date	Measuring time from-to	NO _x -concentration related to 13 % O ₂ of vol. mg/m ³	Date	Measuring time from-to	NO _x -concentration related to 13 % O ₂ of vol. mg/m ³
19/10/2010	09:18-09:48	120	20/10/2010	09:12-09:42	92
	09:48-10:18	120		09:42-10:12	91
	10:18-10:48	121		10:12-10:42	91
	10:48-11:18	120		10:42-11:12	92
	11:18-11:48	121		11:12-11:42	90
	11:48-12:18	121		11:42-12:12	90
	12:18-12:48	122		12:12-12:42	91
	12:48-13:18	123		12:42-13:12	90
	13:18-13:48	123		13:12-13:42	92
	13:48-14:18	122		13:42-14:12	92
14:18-14:48	121	14:12-14:42	91		
14:48-15:18	122	14:42-15:12	91		

5.1.3.3 Half-hour average values pellets boiler type P4 Pellet 100 – organic gaseous substances (OGC)

The determination of gaseous organic carbon substances (OGC) was performed without splitting the individual components with a flame ionisation detector (FID) for which calibration propane was used.

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

OGC-emission fuel wood pellets

Fuel wood pellets – nominal heat output			Fuel wood pellets – minimum heat output		
Date	Measuring time from-to	OGC-concentration related to 13 % O ₂ of vol. mg/m ³	Date	Measuring time from-to	OGC-concentration related to 13 % O ₂ of vol. mg/m ³
19/10/2010	09:18-09:48	< 1	20/10/2010	09:12-09:42	< 2
	09:48-10:18	< 1		09:42-10:12	< 2
	10:18-10:48	< 1		10:12-10:42	< 2
	10:48-11:18	< 1		10:42-11:12	< 2
	11:18-11:48	< 1		11:12-11:42	< 2
	11:48-12:18	< 1		11:42-12:12	< 2
	12:18-12:48	< 1		12:12-12:42	< 2
	12:48-13:18	< 1		12:42-13:12	< 2
	13:18-13:48	< 1		13:12-13:42	< 2
	13:48-14:18	< 1		13:42-14:12	< 2
14:18-14:48	< 1	14:12-14:42	< 2		
14:48-15:18	< 1	14:42-15:12	< 2		

5.1.3.4 Emission values pellets boiler type P4 Pellet 100 – average values in accordance with ÖNORM EN 303-5:1999

The average values determined by firing the fuels chipped wood and wooden pellets for the operating conditions nominal heat output and minimum heat output in accordance with ÖNORM EN 303-5:1999 are given below (average values over the entire test period of in each case 6 hours per operating condition).

Boiler type P4 Pellet 100, fuel wood pellets, average values in accordance with ÖNORM EN 303-5:1999

Parameter	Nominal heat output	Minimum heat output
Date of measurements	19/10/2010	20/10/2010
Measuring time (from – to)	09:18-15:18	09:12-15:12
Heat output useful generated (kW)	99.43	23.67
Oxygen concentration (% of vol.)	4.78	8.81
Emission of carbon monoxide (CO)		
at actual O ₂ (mg/m ³)	17	64
related to 10 % O ₂ (mg/m ³)	11	58
related to 11 % O ₂ (mg/m ³)	10	53
related to 13 % O ₂ (mg/m ³)	8	43
related to the energy content (mg/MJ)	6	29
Emission of nitrogen oxides (NO _x)		
at actual O ₂ (mg/m ³)	247	139
related to 10 % O ₂ (mg/m ³)	167	125
related to 11 % O ₂ (mg/m ³)	152	114
related to 13 % O ₂ (mg/m ³)	122	91
related to the energy content (mg/MJ)	83	62
Emission of gaseous org. substances (OGC)		
at actual O ₂ (mg/m ³)	< 2	< 2
related to 10 % O ₂ (mg/m ³)	< 2	< 2
related to 11 % O ₂ (mg/m ³)	< 2	< 2
related to 13 % O ₂ (mg/m ³)	< 1	< 2
related to the energy content (mg/MJ)	< 1	< 1

5.2 BOILER EFFICIENCY AND COMBUSTION PERIOD DURATION

The efficiency of the biomass heating system was determined according to the formalism of the direct method shown in ÖNORM EN 303-5:1999 (see point 4.1.5 of the report).

Below the calculated results as average of the recorded values are stated for the respective test duration.

Boiler efficiency and combustion period – pellets boiler type P4 Pellet 100, fuel wood pellets

Parameter	Nominal heat output	Minimum heat output
Date of measurements	19/10/2010	20/10/2010
Measuring time (from – to)	09:18-15:18	09:12-15:12
Test duration (hours)	6.0	6.0
Combustion period (hours)	6.0	6.0
Fuel mass added (kg)	131.908	31.587
Fuel mass added per hour (kg/h)	21.98	5.26
Net calorific value of the test fuel, related to raw condition (H_u , kJ/kg)	17270	17270
Heat output useful generated (Q , kW)	99.43	23.67
Heat output (Q_B , kW)	105.47	25.25
Boiler efficiency, direct (%)	94.3	93.7

5.2.1 Exhaust gas loss (loss through sensible heat of the products of combustion)

The exhaust gas losses (loss through sensible heat of the products of combustion) calculated by the formalism in accordance to BGBl. II No 331/1997 (see point 4.1.6) are mentioned below. The input data used for the calculation are presented in point 5.1.1 of the test report.

Input data used for the calculation

t_A exhaust gas temperature °C (measured on the measuring point after flue gas exit of the boiler)

t_L ambient temperature in °C

O_2 dry oxygen content of the flue gas in % of vol.

A_2 0.6650 for biomass with the test fuel wood pellets (water content of the fuel: 7.1 %)

B 0.0103 for biomass with the test fuel wood pellets (water content of the fuel: 7.1 %)

Calculated exhaust gas losses

Fuel wood pellets:

Pellets boiler type P4 Pellet 100, nominal heat output: $q_A = 4.9 \%$

Pellets boiler type P4 Pellet 100, minimum heat output: $q_A = 4.3 \%$

5.3 WATER SIDE RESISTANCE

In the context of type testing the water side resistance was determined for those flows which correspond to the nominal heat output with two temperature differences of $\Delta t = 10$ K and $\Delta t = 20$ K between the flow and return connections of the boiler.

Flow (l/h)	Temperature difference (K)	Differential pressure (hPa)
4300	20	4.3
8600	10	14.3

5.4 SURFACE TEMPERATURES

For the determination of the mean surface temperature at nominal heat output the boiler surface of the pellets boiler type P4 Pellet 100 was divided into 14 incremental areas, whereby a total of 77 measuring points were regarded.

The critical surface temperatures (e.g. boiler doors, operating levers etc.) and the surface temperature at the outside of the boiler bottom were measured at nominal heat output (under the same conditions).

In the case of the boiler type in question, the inner boiler doors at the front are shielded from the possibility of direct contact by a second, fully covering insulating door.

The following table shows a summary of the surface temperatures measured on the operator side in the course of the tests and the room temperature at the time of the surface temperature measurements.

Pellets boiler type P4 Pellet 100, measuring date 19/10/2010, maximum values of the surface temperatures

Operating condition	Covering panel	Doors, cleaning port covers	Outside of the boiler bottom	Operating levers	Room-temp.
	maximum value	maximum value	maximum value	maximum value	
Fuel wood pellets (nominal heat output)	47°C	46°C	41°C	35°C (metal)	20°C

In all tests the mean surface temperature of boiler doors and cleaning port covers on the operator side did not exceed the permissible temperature difference of 100 K against room temperature in accordance to ÖNORM EN 303-5:1999.

The surface temperature on the outside of the boiler bottom did not exceed the room temperature by more than 65 K.

The surface temperatures of the operating levers and all parts which shall be touched by hand during operation of the boiler did not exceed the room temperature by more than 35 K.

5.5 AUXILIARY POWER CONSUMPTION

The average values of auxiliary power consumption, determined in the context of the in the context of the emission behaviour tests and the boiler efficiency tests of the unit, and the ascertained auxiliary power consumption in sleeping operation, the ignition process and key consumers are listed in the tables below.

The boiler water circulation pump has to be provided usually by the client on site according to the specification of the boiler manufacturer and is not included in the test results.

Biomass boiler type: pellets boiler P4 Pellet 100
Test period: 18/10/2010 – 22/10/2010

Date	Parameter	Measuring time from – to	Test duration	Auxiliary power consumption
19/10/2010	Nominal heat output (99.43 kW)	09:18-15:18	6.0 h	Mittelwert: 112 W
20/10/2010	Minimum heat output (23.67 kW)	09:12-15:12	6.0 h	Mittelwert: 49 W
22/10/2010	Ignition process (electrical work)	09:08-09:19	11 min	83 Wh
18/10/2010	Sleeping operation (average)	15:00-16:00	60 min	10 W
18/10/2010	Key consumers			
	- fan motor (exhaust fan) – 100 %			114 W
	- fan motor (exhaust fan) – 66 %			106 W
	- fan motor (exhaust fan) – 25 %			54 W
	- motor for cleaning of heating surfaces			65 W
	- motor for discharging flue ash			115 W
	- fuel discharge (suction device)			1560 W
	- stoker screw conveyor			78 W
	- back-burning damper motor			12 W

5.6 FUNCTION CHECK OF THE TEMPERATURE CONTROLLER AND THE SAFETY TEMPERATURE LIMITER

The function check of the temperature controller and the safety limiter of the pellets boiler type P4 Pellet 100 was performed according to ÖNORM EN 303-5 in the context of the emission behaviour tests and the boiler efficiency tests of the unit.

For the determination of the flow temperatures and the boiler temperatures the temperature sensors of the boiler manufacturer installed at the unit were used.

Before test execution these sensors were compared with a calibrated Pt100-temperature sensor of the TÜV AUSTRIA SERVICES GMBH and they indicated properly.

5.6.1 Function check of the temperature controller and the safety limiter installed at the heating boiler

Before starting the test the water-side flow rate was fixed to the specified flow for the rated output test. Afterwards the firing of the unit was adjusted corresponding to the rated heat output of the boiler. At the start of the test the flow temperature did not exceed a value of 75°C and the boiler temperature controller was adjusted to the maximum set value of 80°C specified by the boiler manufacturer.

Afterwards the dissipated output was limited to 40 % of the nominal heat output.

The test was continued up till the temperature controller reacts, and afterwards the temperature was observed at which the boiler maximum temperature was reached.

The same test was repeated with the temperature controller out of function. In this test the safety temperature limiter has to switch off the heating at the highest value of maximum 100°C specified by the boiler manufacturer.

5.6.2 Function check on the device for dissipating excess heat

During this test the heating boiler was operated at the highest heat output and the temperature controller was deactivated.

The function of the safety temperature limiter was maintained.

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

5.6.3 Test results

5.6.3.1 Function check of the temperature controller installed at the pellets boiler type P4 Pellet 100

Conditions 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:	72.4°C
Boiler temperature controller:	set value 80°C (as specified by manufacturer)
Dissipated output:	approx. 40 % of the nominal heat output
Safety temperature limiter:	response point for switch off at 100°C

Test results

The control being installed at the boiler operated correctly.

The control being installed at the boiler switched off the firing at a temperature at the measuring point boiler temperature of 83°C.

Afterwards the temperature at the measuring point boiler temperature still rose up to 90°C.

The safety temperature limiter did not trigger.

The requirements of the ÖNORM EN 303-5:1999 regarding function of the temperature controller were fulfilled by the tested pellets boiler type P4 Pellet 100.

5.6.3.2 Function check of the safety temperature limiter installed at the heating boiler P4 Pellet 100

Conditions 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:	73.6°C
Boiler temperature controller:	temperature controller deactivated
Dissipated output:	approx. 40 % of the nominal heat output
Safety temperature limiter:	response point for switch off at 100°C

Test results

The safety temperature limiter switched off the firing of the heating boiler at a temperature at the measuring point boiler temperature of 96.4°C.

Afterwards the temperature at the measuring point boiler temperature still rose up to 99.9°C.

The requirements of the ÖNORM EN 303-5:1999 regarding function of the safety temperature limiter were fulfilled by the tested pellets boiler type P4 Pellet 100.

5.7 CO-SAFETY

Within the measurements for the determination of the emission behaviour (see point 5) and the function checks of the safety devices (see point 5.6) no dangerous accumulation of combustible gases occurred in the combustion chamber and the flue gas passages.

5.8 RADIATION LOSS

The radiation loss of the boiler type was determined on the basis of DIN 4702-2 and ÖNORM EN 304 from the surface temperatures of the unit being measured in the context of the emission behaviour tests.

The stated percentage-wise value of the radiation loss is referred to the useful generated heat output in the test period. The calculated values are given below.

Calculated radiation losses, date of measurements 19/10/2010 and 20/10/2010:

Nominal heat output, pellets boiler type P4 Pellet 100:	$q_s = 0.51 \%$
Minimum heat output, pellets boiler type P4 Pellet 100:	$q_s = 1.82 \%$

6. SUMMARY

The Fröling Heizkessel- und Behälterbau GesmbH assigned the TÜV AUSTRIA SERVICES GMBH with the test of the pellets boiler type P4 Pellet 100 in the extent as described below.

- a) Type test performance in accordance with ÖNORM EN 303-5:1999
- b) Verification of the compliance with the applicable regulations of the agreement of the Austrian Federal States according to article 15a of the Federal Constitution about "Schutzmaßnahmen betreffend Kleinf Feuerungen" and about "Einsparung von Energie" at test time.
- c) Verification of the compliance with the applicable regulations of the Austrian Federal Law Gazette Part II No. 331/1997 (FAV, BGBl. II No. 331/1997, regulation concerning heating systems) at test time.

Furthermore, in the context of the type test, a determination of the auxiliary power consumption should be done of the key consumers and in the following modes of operation:

- Nominal heat output (average value, measuring time ≥ 6 h)
- Minimum heat output (average value, measuring time ≥ 6 h)
- Sleeping operation (average value, measuring time ≥ 10 min)
- Ignition process (electrical work)

The tests took place at the test rig which is set up at the Fröling Heizkessel- und Behälterbau GesmbH, which was equivalent with the requirements of the ÖNORM EN 303-5:1999 at test date.

As test fuel the fuel wood pellets was fired in the biomass boiler type which corresponded to the layout given in the manufacturer information.

For the subject boiler type of the make Fröling, type P4 Pellet 100, an EC Declaration of Conformity of the boiler manufacturer to Machinery Directive 2006/42/EG is on hand of TÜV AUSTRIA SERVICES GMBH, in which the conformity in the characteristic as central heating boiler for solid fuels according to EN 303-5:1999 is declared with the regulations of EC Directives 2006/42/EC (Machinery Directive), 2006/95/EC (Low Voltage Directive) and 2004/108/EC (EMC Directive) in the following relevant references:

- EN ISO 12100-1:2004
- EN 60335-1:2007
- EN 61000-6-2:2005 and EN 61000-6:2007

A copy of the production documents, showing the relevant drawings, the production controls, the execution of welding work, the welding seams and welding fillers, the wall thicknesses and the safety designs, was submitted to TÜV AUSTRIA SERVICES GMBH and is kept for perusal at the test centre Thalheim/Wels.

On examination of the production documents submitted to TÜV AUSTRIA SERVICES GMBH no deviation from the construction requirements of ÖNORM EN 303-5:1999 was found in the construction.

Furthermore the temperatures of the surfaces, determined at nominal heat output, and the tested safety devices (temperature controller, safety temperature limiter) fulfilled the requirements of ÖNORM EN 303-5:1999 (see point 5.4 and 5.6 of the test report).

The values of water-side resistance, ascertained within the type test, are given in point 5.3, the measured values of auxiliary power consumption are given in point 5.5 and the ascertained radiation losses are given in point 5.8 of the test report.

The pellets boiler type P4 Pellet 60 showed exhaust gas temperatures below 160 K above room temperature in the context of the type tests performed by TÜV AUSTRIA SERVICES GMBH at nominal heat output (see point 5.1.1).

Therefore the boiler manufacturer shall make recommendations in the installation instructions regarding the flue installation in order to ensure sufficient draught and to prevent sooting up of the chimney and condensation.

Furthermore the range of the draught in accordance to the design shall be specified, and the correct and safe operation of the unit and information about the risks caused by improper operation has to be noted in the operating instructions.

The boiler installation shall be carried out increasing towards the flow connection. For venting the water section a venting appliance shall be provided by customer according to manufacturer information.

The correct installation of the heating boiler (increasing towards the flow connection), the preparation of a corresponding connection in the flow needed by customer and the venting procedure has to be included in the installation instructions and in the operation instructions.

An EMC-compatibility test of the control model used in the pellets boiler type (control model type Lambdatronic P 3200) was carried out at TÜV AUSTRIA SERVICES GMBH in the context of type test.

The evaluation of the fire protection system of the back burning safety device installed in the boiler unit was made in a separate expertise by the IBS (Institute for Fire Protection Engineering and Research Ltd.) according to prTRVB H 118.

The boiler manufacturer has to ensure that all boilers of the tested pellets boiler type P4 Pellet 100 comply to the requirements of the ÖNORM EN 303-5:1999.

The emission values, boiler efficiencies and exhaust gas losses (losses through sensible heat of the products of combustion) determined in the context of the tests are shown below in accordance to the ÖNORM EN 303-5:1999 as arithmetic average values over the entire test duration of in each case 6 hours per operating condition.

The detailed test results and the individual half-hour average values of the emission concentrations (referred to a hypothetical oxygen contents of 13 % O₂) are given in point 5.1 of the test report.

6.1 EMISSION VALUES – PELLETS BOILER TYPE P4 PELLET 100

Parameter	Nominal heat output	Minimum heat output
Date of measurements	19/10/2010	20/10/2010
Measuring time (from – to)	09:18-15:18	09:12-15:12
Heat output useful generated (kW)	99.43	23.67
Oxygen concentration (% of vol.)	4.78	8.81
Emission of dust		
at actual O ₂ (mg/m ³)	37	24
related to 10 % O ₂ (mg/m ³)	25	21
related to 11 % O ₂ (mg/m ³)	23	19
related to 13 % O ₂ (mg/m ³)	18	15
related to the energy content (mg/MJ)	13	10
Emission of carbon monoxide (CO)		
at actual O ₂ (mg/m ³)	17	64
related to 10 % O ₂ (mg/m ³)	11	58
related to 11 % O ₂ (mg/m ³)	10	53
related to 13 % O ₂ (mg/m ³)	8	43
related to the energy content (mg/MJ)	6	29
Emission of nitrogen oxides (NO _x)		
at actual O ₂ (mg/m ³)	247	139
related to 10 % O ₂ (mg/m ³)	167	125
related to 11 % O ₂ (mg/m ³)	152	114
related to 13 % O ₂ (mg/m ³)	122	91
related to the energy content (mg/MJ)	83	62
Emission of gaseous organic substances (OGC)		
at actual O ₂ (mg/m ³)	< 2	< 2
related to 10 % O ₂ (mg/m ³)	< 2	< 2
related to 11 % O ₂ (mg/m ³)	< 2	< 2
related to 13 % O ₂ (mg/m ³)	< 1	< 2
related to the energy content (mg/MJ)	< 1	< 1

6.2 BOILER EFFICIENCY AND EXHAUST GAS LOSS – PELLETS BOILER TYPE P4 PELLET 100

Test fuel	Operating condition	Exhaust gas loss %	Boiler efficiency %, direct method
wood pellets	nominal heat output (99.43 kW)	4.9	94.3
wood pellets	minimum heat output (23.67 kW)	4.3	93.7

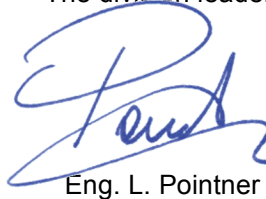
6.3 INTERPRETATION OF THE TEST RESULTS

The results of the test of the pellets boiler type P4 Pellet 100 of the company Fröling Heizkessel- und Behälterbau GesmbH, which has been performed in the period of 18/10/2010 – 05/11/2010, adhered to the limits of emission values, the boiler efficiencies and the exhaust gas losses of the following Standards, which are valid at the time of the test period and that are mentioned in point 1.7, by firing the fuel type wood pellets:

- ÖNORM EN 303-5:1999, boiler class 3 (including the deviations from Austria)
- Art. 15a B-VG – Agreement between the Austrian Federation and the Austrian Federal States about “Schutzmaßnahmen für Kleinfeuerungen” and about “Einsparung von Energie”
- Austrian regulation concerning heating systems (FAV, BGBl. II No. 331/1997)

TÜV AUSTRIA SERVICES GMBH
Test Centre Wels
Division Environmental Protection

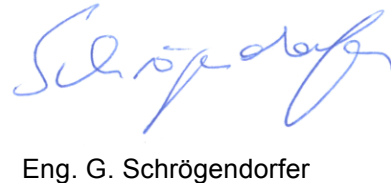
The division leader:

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Eng. L. Pointner

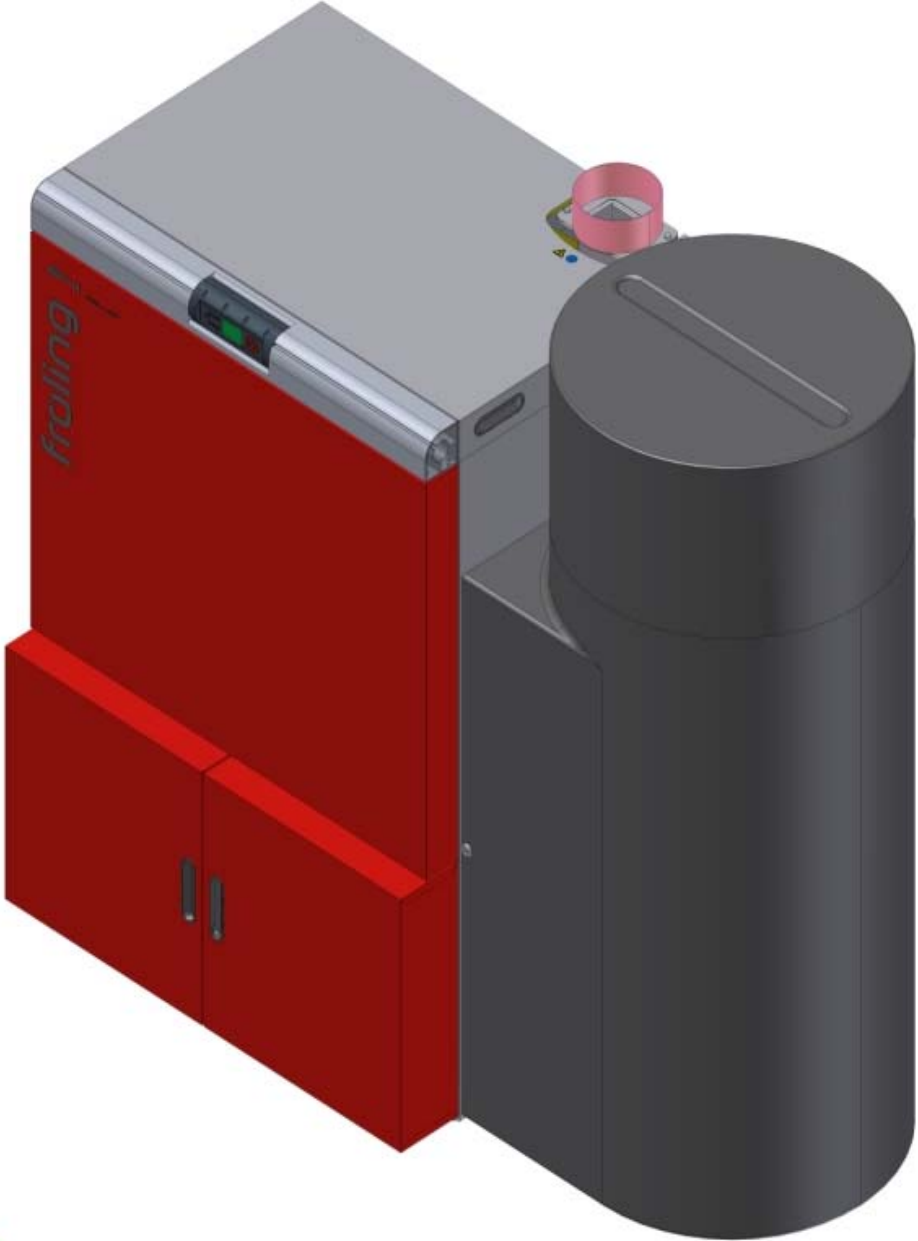


The authorized signatory:

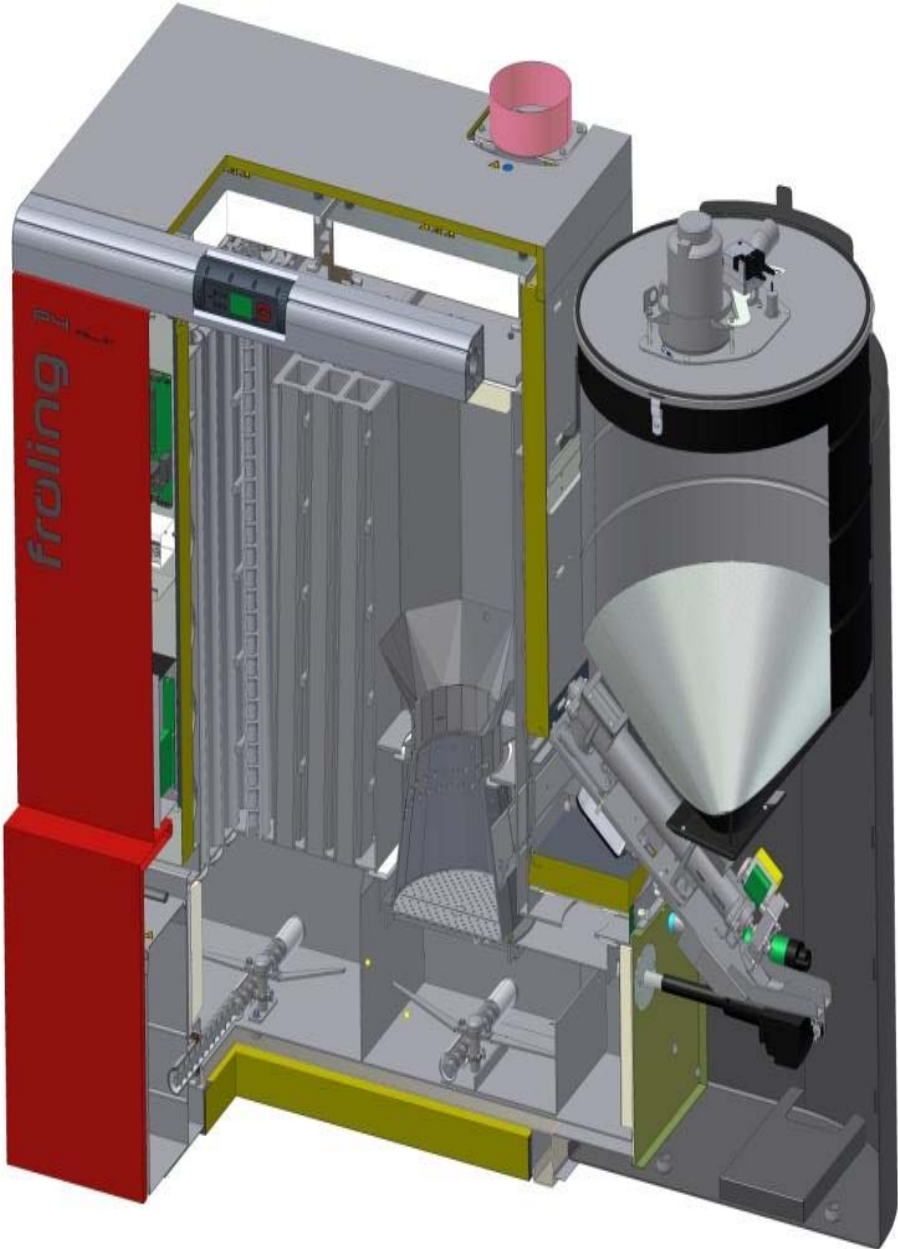
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Eng. G. Schrögendorfer

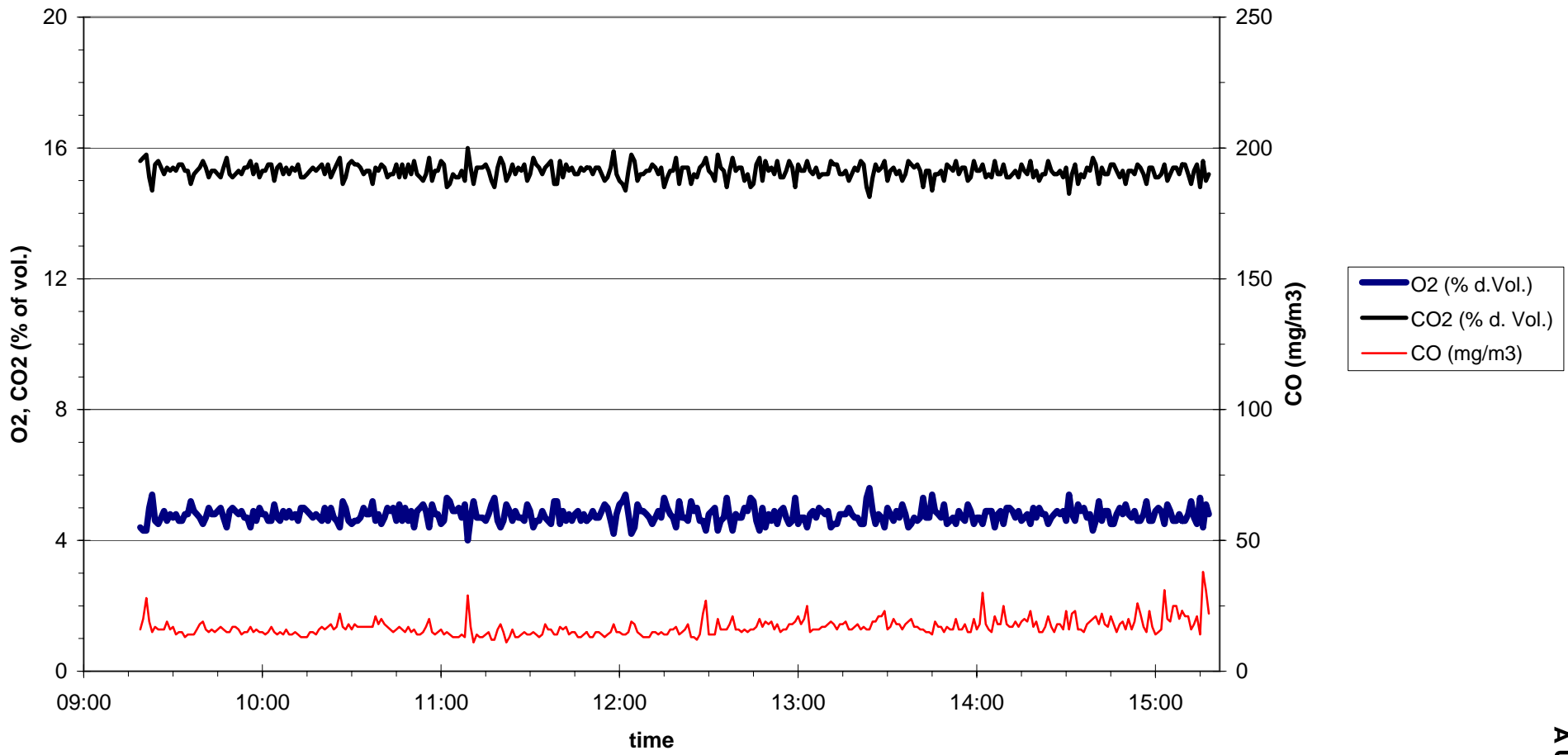
Photo – boiler type P4 Pellet 100



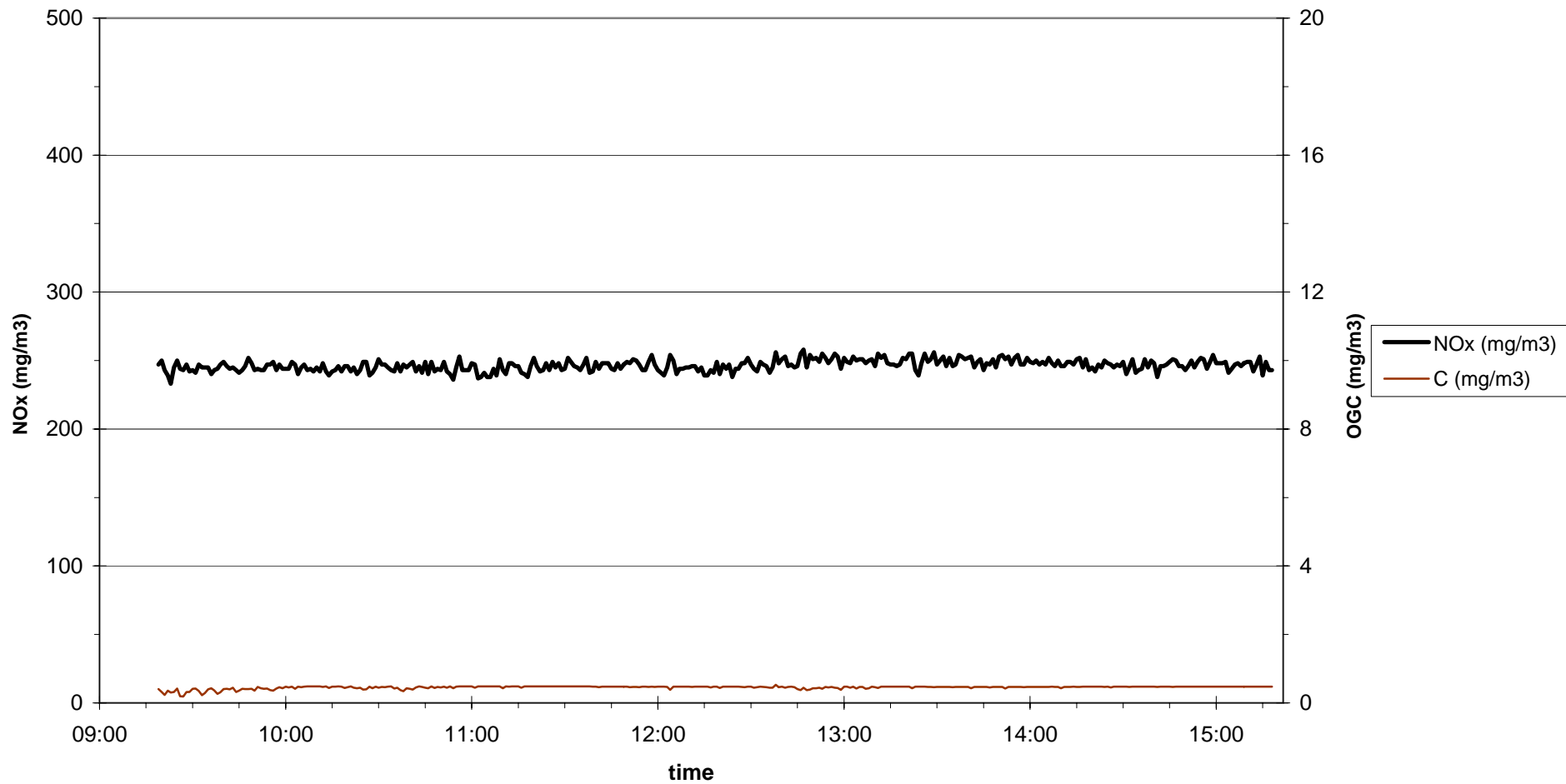
Assembly scheme – boiler type P4 Pellet 100



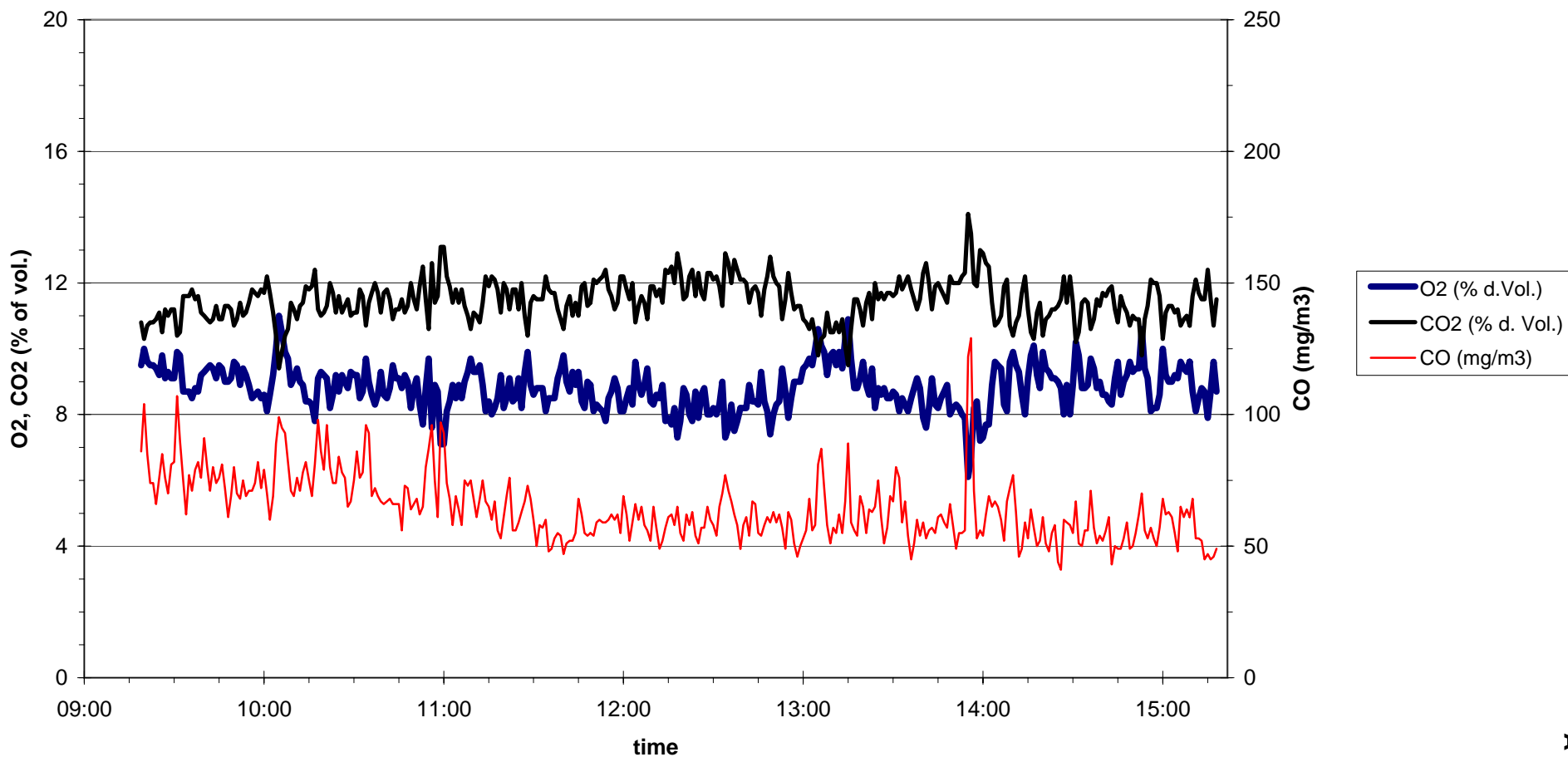
Boiler type P4 Pellet 100 - nominal heat output
Emission concentrations of O2, CO2 and CO - measuring date 19/10/2010
(concentrations referred to a dry flue gas basis at 0°C, 1013 hPa and actual O2)



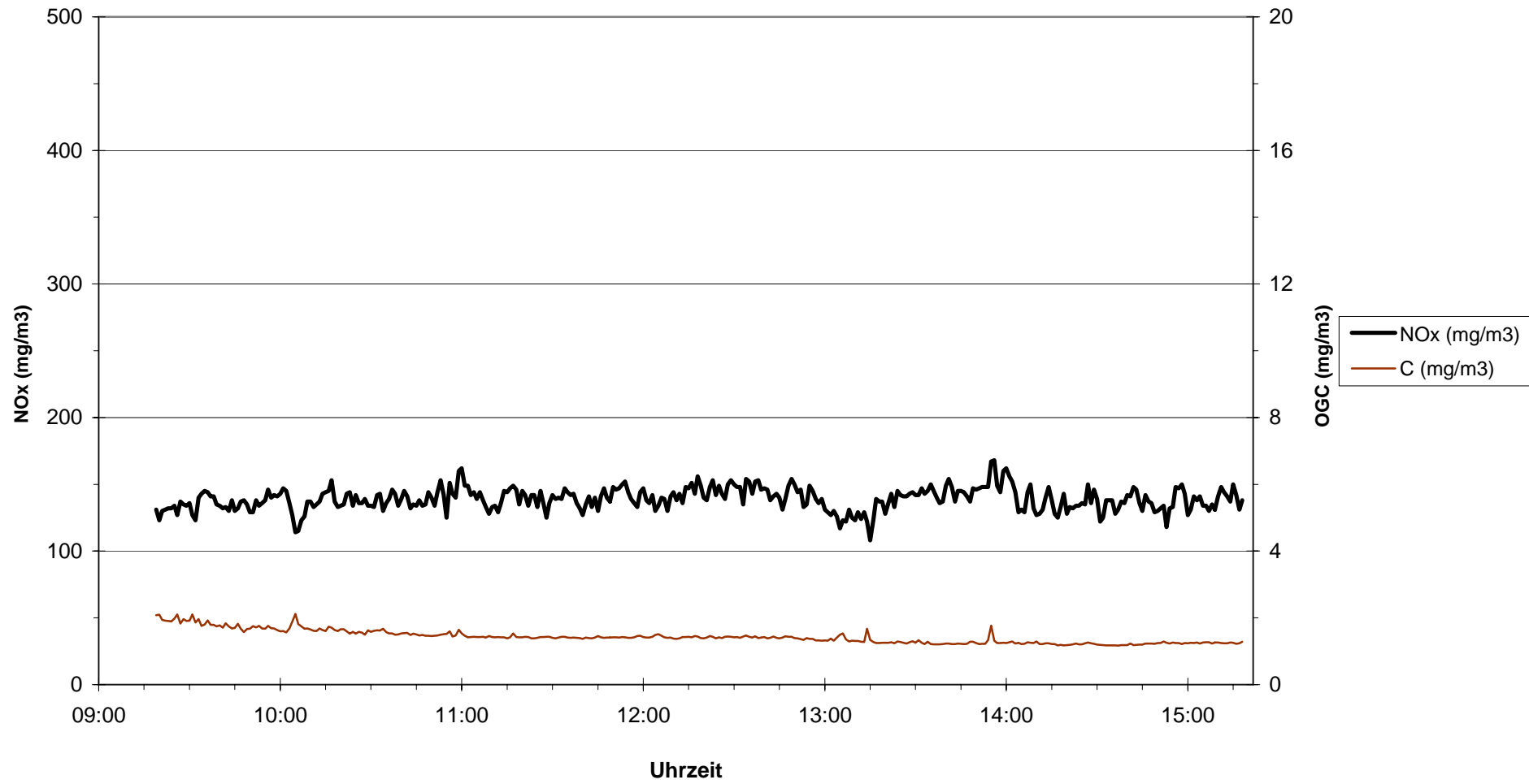
Boiler type P4 Pellet 100 - nominal heat output
Emission concentrations of NOx and OGC - measuring date 19/10/2010
(concentrations referred to a dry flue gas basis at 0°C, 1013 hPa and actual O2)



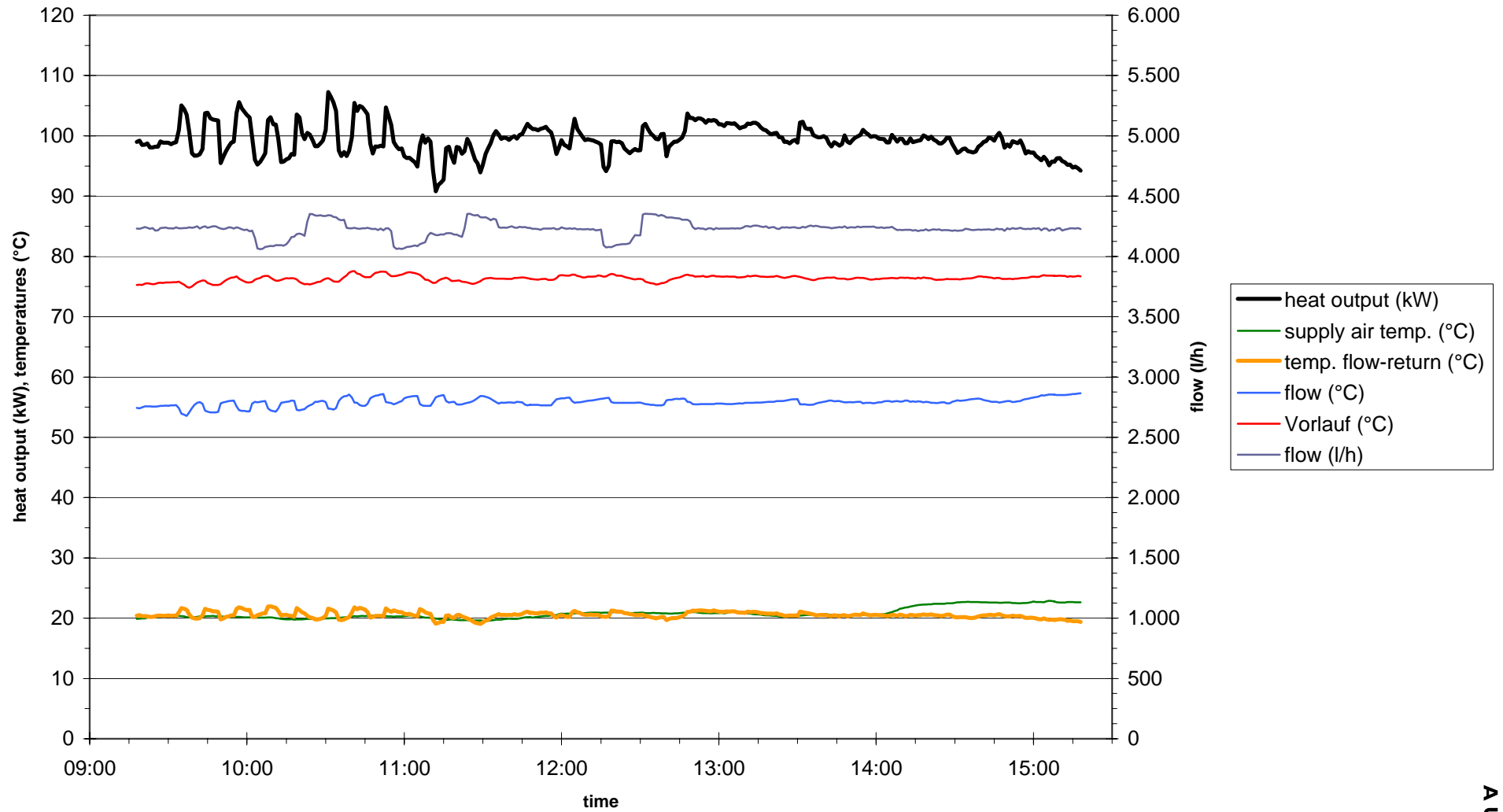
Boiler type P4 Pellet 100 - minimum heat output
Emission concentration of O₂, CO₂ and CO - measuring date 20/10/2010
(concentrations referred to a dry flue gas basis at 0°C, 1013 hPa and actual O₂)



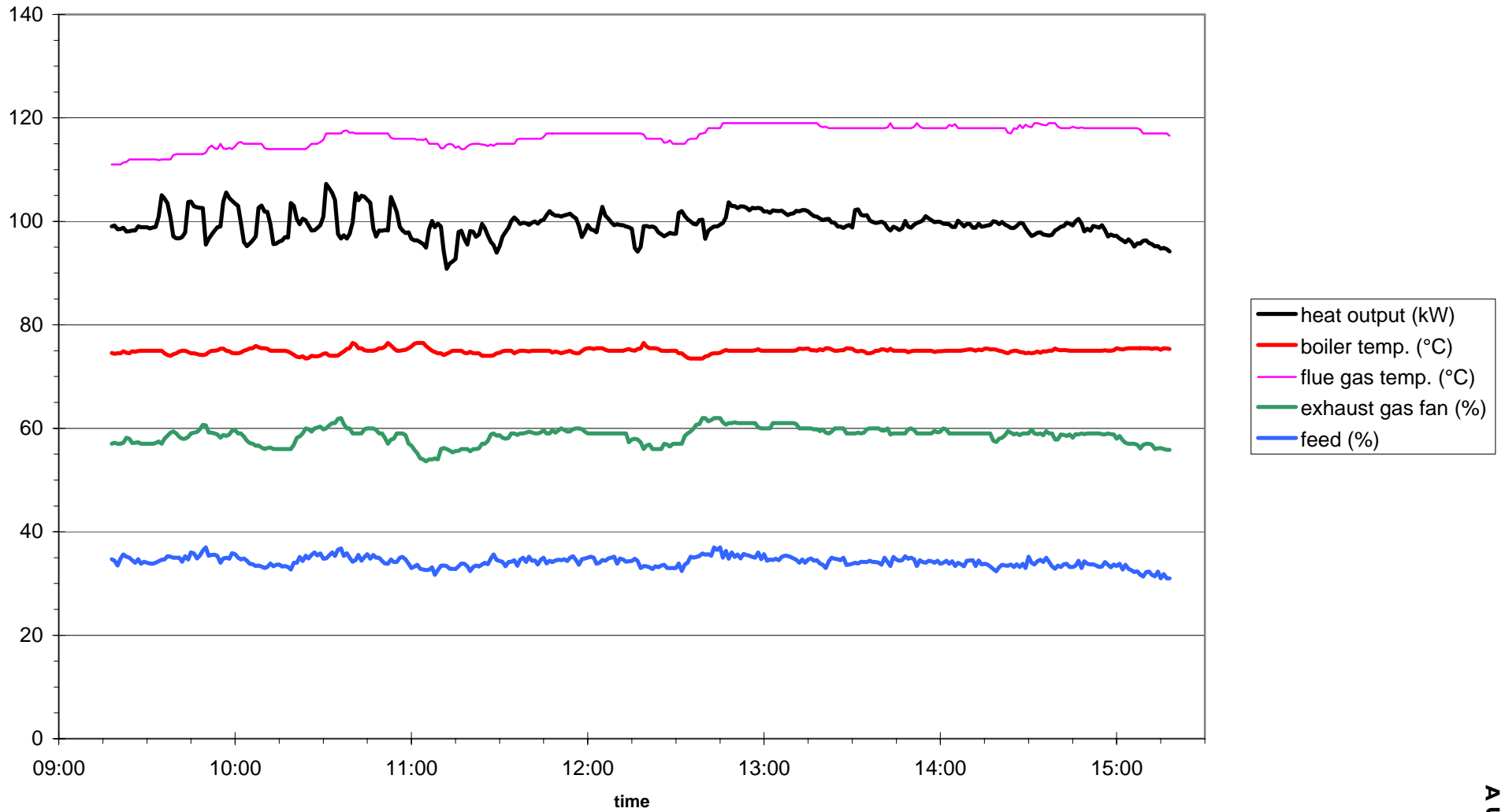
Boiler type P4 Pellet 100 - minimum heat output
Emission concentrations of NOx and OGC - measuring date 20/10/2010
(concentrations referred to a dry flue gas basis at 0°C, 1013 hPa and actual O2)



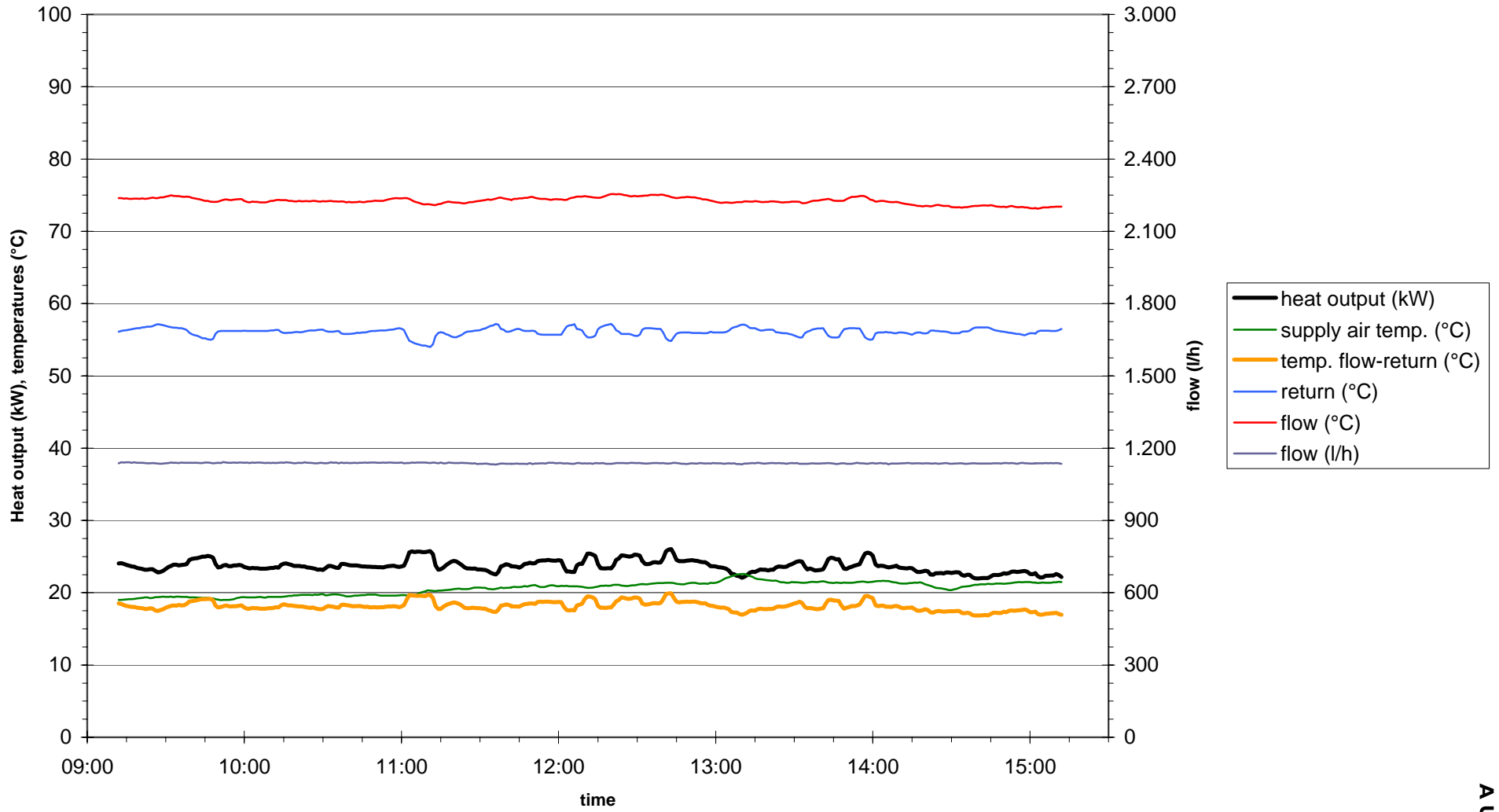
Pellets boiler P4 Pellet 100, nominal heat output - heat output, 19/10/2010



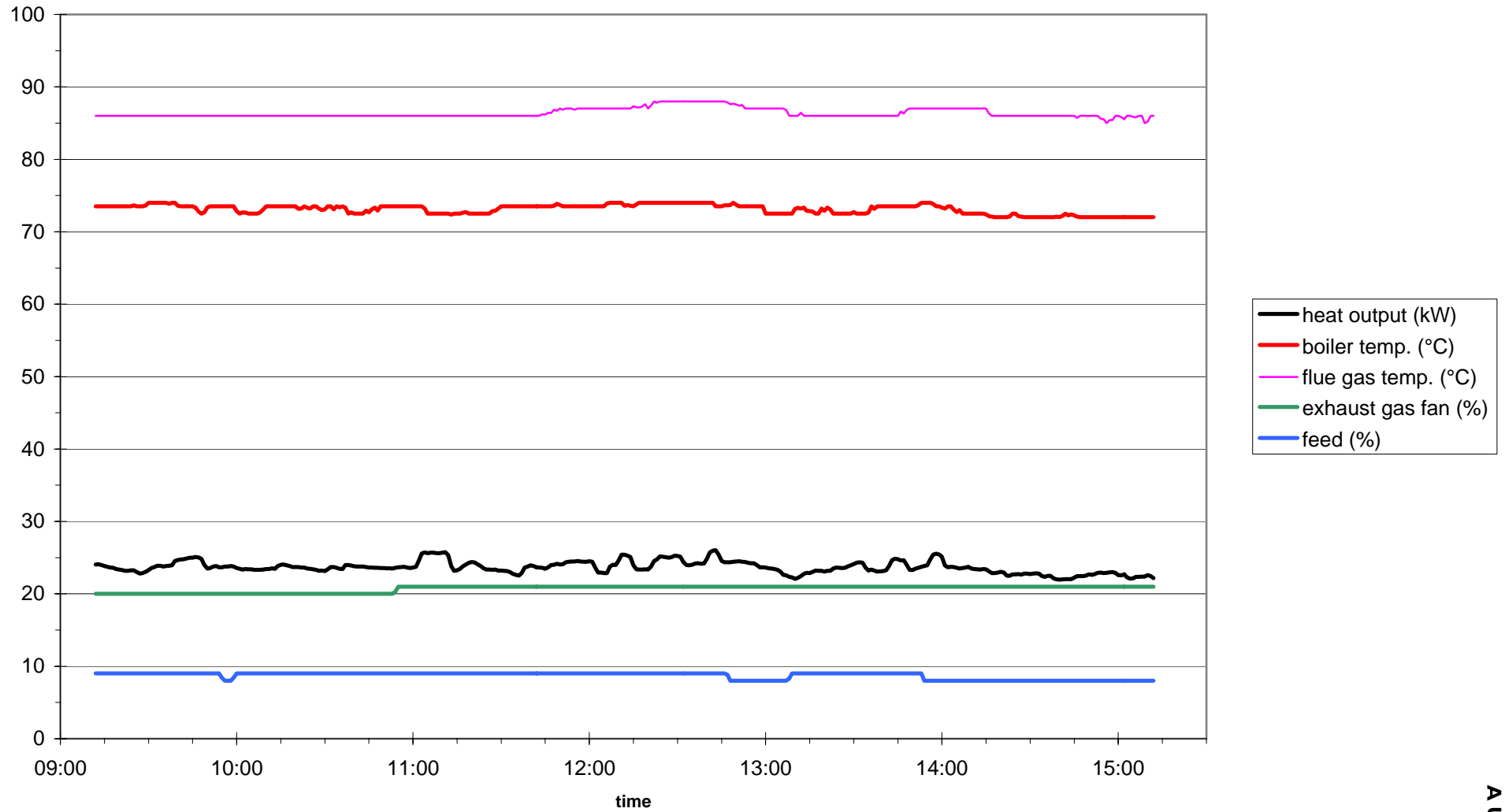
Pellets boiler P4 Pellet 100, nominal heat output - boiler data, 19/10/2010



Pellets boiler P4 Pellet 100, minimum heat output - heat output, 20/10/2010



Pellets boiler P4 Pellet 100, minimum heat output - boiler data, 20/10/2010



List of test documents submitted to TÜV AUSTRIA SERVICES GMBH by the boiler manufacturer for the pellets boiler type P4 Pellet 100

- Operating instructions boiler types P4 Pellet, Fröling doc. no. B 043 06 10
- Installation instructions boiler types P4 Pellet, Fröling doc. no. M 093 06 10
- Rating plate boiler type P4 Pellet 100
- Photo and assembly scheme of the boiler type P4 Pellet 100
- Construction drawings P4 Pellet 100, complete list
- Supply specification and test data sheet of the exhaust gas fan
- Confirmation of conformity with DIN 3440 and VDE mark approval for the temperature controller and limiter device make T&GSpA, type TG400-94L100
- Data sheet of the lambda probe LSU, company bosch
- Technical data sheet of flap drives, model Belimo BLF24
- Test report EMVC 200708111 from EMV Consulting about the EMC compatibility of the electronic boiler control / heating control for pellets boiler type P4 incl. supplementary report EMVC 2009-02-10
- Report of TÜV SÜD Rail GmbH, no. FG81883T from 10/08/007 and 17/06.2010 about the test of modules for pellet heating boiler P4 Pellet according to EN 60335-1/A2:06 and EN 60335-2-102:06
- Test certificates according to EN 10204:2004
- EC type examination certificate and test certificate for the compact ultrasonic heat meter of the make Hydrometer Ultra SII (heat meter used by testing incl. calculation unit)
- Product data sheet of the measuring device for the determination of auxiliary power consumption
- Acceptance test certificate of the rating test of the pellets boiler type P4 Pellet 80/100/105 issued by Fröling on 19/10/2010
- EC declaration of conformity according to Machinery Directive for the pellets boiler type range P4 Pellet, issued by Fröling
- Fire protection product evaluation, made by the IBS (Institute for Fire Protection Engineering and Research Ltd.) for the pellets heating boiler P4 type range with suction feeding
- TÜV Cert certificate from the TÜV Cert certification body of TÜV Austria, reg. no. 20 100 6394, proof of requirements as per EN ISO 9001:2008 for the scopes design, production, sales and service of biomass heating systems
- Certificate no. A/027/07 issued from TÜV AUSTRIA SERVICES GMBH, certificate of fulfilment of the conditions of § 14 Austrian boiler law (BGBl. No. 211/1992)
- Test log as per ÖNORM M 7812 part 1, test number 2391/Sp/80
- Certificate no. PZ/08/S/111/SCHOE from TÜV AUSTRIA SERVICES GMBH regarding fulfilment of the welding quality requirements in line with ÖNORM EN ISO 3834-2
- Certificate list of material standards used in the boiler type P4 Pellet 100, created by Fröling