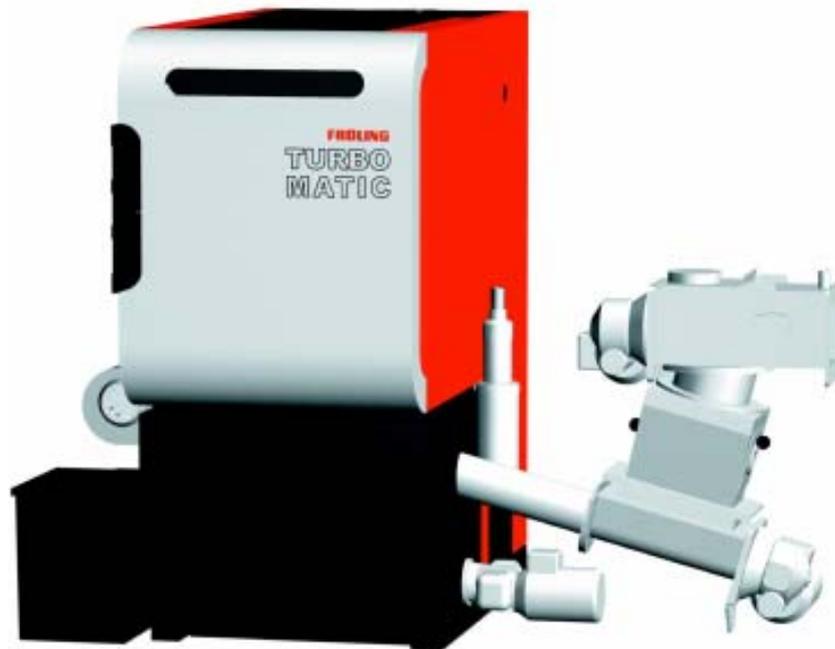


BLT reference no: 244/01

BLT approval number: 005/02

TEST REPORT



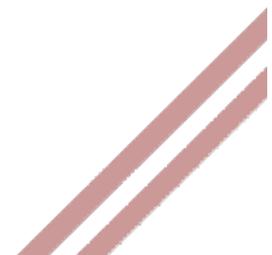
### Heating boiler for chipped wood Type Turbomatic 110

**Applicant:**

Fröling Heizkessel- und  
Behälterbau GmbH  
Industriestraße 12  
AT 4710 GRIESKIRCHEN

**Manufacturer:**

Same as applicant



BLT Wieselburg is accredited as testing station for combustions, identification number 112, according to accreditation law, Federal Law Gazette No. 468/1992 and its quality management is up to standard of ÖVE/ÖNORM EN ISOIEC 17 025.



**FRANCISCO JOSEPHINUM WIESELBURG**  
**BLT – BIOMASS | LOGISTICS | TECHNOLOGY**

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Fax: +43-7416-52175-45  
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Internet: <http://blt.josephinum.at>

**Authorized translation (abridged version)**  
**In the event of doubt, the German original shall prevail.**

**The test report must be published only literally and unabridged.**  
**Exceptions must be authorized by FJ-BLT.**

**Flue gas recirculation is no longer offered by the manufacturer**  
**and is therefore not included in the report.**

## **DESCRIPTION**

The tested heating boiler, type Turbomatic 110 for chipped wood and wood pellets manufactured by Fröling Heizkessel- und Behälterbau GmbH with a nominal heat output of 110 kW consists of a supply bin, a fuel feeding system, a gravity shaft, a fire bricked combustion chamber with ash removal equipment and a downstream boiler for heat exchange. The whole system is operated by a microprocessor-controller, modular control panel.

The supply bin used in the test is made of cylindrical elements. A rotary stirrer at the base of the bin is powered together with a discharge screw by a geared motor and transports fuel to the gravity shaft. There the system features a spring type electric back-fire flap which separates discharge and stoker screw. From the gravity shaft the chipped wood is fed onto the grate via the stoker screw.

The combustion unit is fully heat insulated and mounted detachable. The walls of the combustion chamber are lined with fire brick which also serves for the circulating upward guide of secondary air. The grate can be shaken and tipped which enables the injection of primary air as well as the even dispersal of fuel on the grate and an automatic cleaning of combustion residues. At the bottom of the combustion unit an ash discharge screw feeds the residues into the lateral ash bin. A second ash screw in the settling chamber underneath the tubular heat exchanger feeds the fly ashes in a separate ash bin. The radial fan (for a controlled flow of combustion air) as well as the induced draft fan (which ensures the required low pressure in the combustion chamber) is speed controlled.

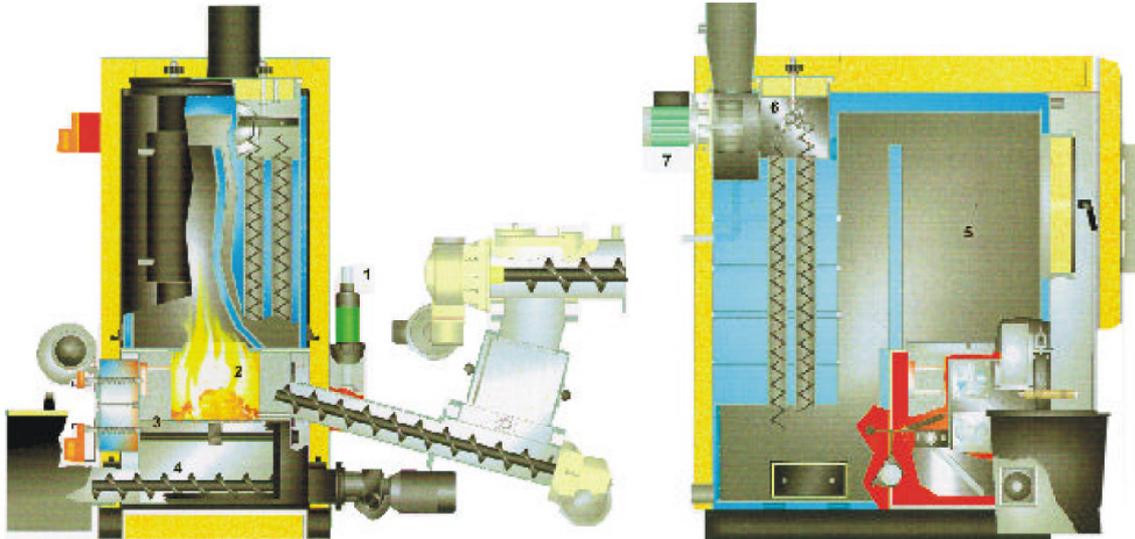
The microprocessor control unit is designed to ensure automatic operation of the system. When the system is switched on, fuel is fed into the combustion unit and ignited with an electric ignition device. When the boiler is reaching the set temperature, primary air and the amount of fuel is regulated accordingly. Secondary air and combustion air flow are controlled by an oxygen (Lambda-) probe and adapted to the actual type of fuel. (Lambda probe).

## **INFORMATION ON COMPANY NAMEPLATE**

Fröling Heizkessel- u. Behälterbau Ges.m.b.H  
4710 Grieskirchen, Industriestraße 12

Chipped wood boiler type	Turbomatic 110
Serial number	110.0001 . M. 03
Year of construction	2001
Nominal heat output	110 kW
Output range	33 - 110 kW
Permitted fuel ÖNORM M 7133/ ÖNORM M 7135	Chipped wood/ wood pellets
Fuel heat capacity	121,5 kW
Max. permitted operating temperature	95 °C
Max. permitted operating pressure	3 bar
Boiler class	3
Water capacity	320 litres
Electrical connection	400 V; 50 Hz; 13 A; 650 W

**DIAGRAM OF COMBUSTION SYSTEM**



- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>1 Automatic ignition</li> <li>2 Fire bricked combustion chamber</li> <li>3 Shaking grate with automatic tipping mechanism</li> <li>4 Ash removal screw in ashcan</li> </ul> | <ul style="list-style-type: none"> <li>5 Fuel loading chamber for manual firewood operation</li> <li>6 Automatic heat exchanger cleaner</li> <li>7 Induced draught fan for low-pressure operation</li> </ul> |
|--|--|

**TECHNICAL SPECIFICATIONS**

Overall width including bin .....	4630	mm
Overall depth including ID fan .....	2090	mm
Overall height .....	1900	mm
Total weight (weight of boiler with stoker unit and gravity shaft).....	1206	kg
Combustion door.....	410 x 330	mm
Flue pipe diameter .....	200	mm
Height up to top edge of flue pipe connection (vertical) .....	1900	mm
Outfeed/return feed connection .....	6/4	"
Sheet thickness of surfaces coming into contact with fire .....	6	mm
Thermal insulation .....	60 - 110	mm
Water content (measured) .....	294	l

## **MEASUREMENTS ON THE TEST STAND**

Measurements were taken to determine the heat output, the boiler efficiency rating (direct method), the composition of the flue gas, the exit flue temperature in the measuring section, the feed pressure (draw), the emissions behaviour and the electrical power consumption. The surface temperatures were measured at the nominal heat output in a steady operating condition. The surface losses were estimated.

The measuring equipment and the measurement procedure meet the requirements of ÖNORM EN 303-5 and EN 304.

### **TEST SET-UP**

**BOILER TEST STAND WITH HEAT EXCHANGER:** Heat output measured by taking a direct reading of the amount of water circulating and its temperature increase (DIN 4702-2).

**FLUE GAS REMOVAL** over vertical measuring section, feed pressure generated by prefabricated chimney, diameter 200 mm, height above ground 9 m, feed pressure limited by draught limiter flap.

**HEAT OUTPUT MEASUREMENT:** Flow volume with Promag 33 F electromagnetic flow meter and mass flow with Coriolis mass flow meter Promass 63 F by Endress & Hauser, water temperatures at boiler inflow and outflow with Pt 100 resistance thermometer, 1/3 DIN, calibrated in pairs.

**EXIT FLUE TEMPERATURE** in the measuring section by system measurement with five thermocouples.

**FEED PRESSURE** with ring balance.

**CARBON DIOXIDE AND CARBON MONOXIDE CONTENT:** Non-dispersive NGA 2000 infrared gas analyser by Fisher-Rosemount; carbon dioxide: smallest measuring range 0 - 5 %, largest measuring range 0 - 20 %; carbon monoxide: smallest measuring range 0 - 400 ppm, largest measuring range 0 - 20000 ppm; determination in dry flue gas.

**DUST CONTENT:** Ströhlein dust meter with a nominal suction amount of 4 m<sup>3</sup>/h, dust separation on plugged quartz wool filter; filter directly after sampling probe and angle bend, determination of partial current volume with dry gas meter and upstream drying tower. The sampling point for determining the dust content is located directly after the measuring section.

**CONTENT OF ORGANIC GASEOUS SUBSTANCES:** JUM flame ionisation detector, type VE 5; sampling over heated filter and heated cable (thermostatised to 180 °C); determination in damp flue gas.

**NITROGEN MONOXIDE CONTENT:** ECO PHYSICS gas analyser type CLD 700 el-ht; chemiluminescence measuring principle; sampling over heated filter and heated cable, determination in damp flue gas and TECAN AG gas analyser type CLD 502, chemiluminescent; sampling over heated filter and heated cable, gas cooled, determination in dry flue gas.

**DATA LOGGING** with Schlumberger Scorpio SI 3535D data logger, 10 second polling, averaging over 6 measurements, averages saved to data carrier.

## TESTING

**HEAT OUTPUT:** Measurements were taken according to ÖNORM EN 303-5 at the nominal heat output and the minimum heat output (< 30 % of the nominal heat output). When measuring the nominal heat output, the combustion system was in operation within the nominal heat output range for at least three hours before the first measurement. The measuring process itself spanned a period of at least six hours.

**EMISSIONS:** The measurements were performed according to ÖNORM EN 303-5. The dust and nitrogen oxide emissions were only calculated at the nominal heat output. Carbon dioxide, carbon monoxide, organic carbon and nitrogen oxide were averaged over the whole testing period. When determining the dust content, the extraction duration for each filter was limited to 30 minutes. The dust content was determined from 6 averages, evenly spread over the test period. The gas analysers were checked with the relevant calibration gases before and after each test period.

**SETTING:** The results shown refer to reproducible tests with optimised settings. The settings were made in a preliminary test using the manufacturer's recommendations. The aim was to achieve the highest possible carbon dioxide content with the lowest possible carbon monoxide content.

**FUEL:** The measurements were performed with the fuels chipped spruce wood (water content  $w = 27.2\%$ ,  $w = 28.3\%$ ) and wood pellets as per ÖNORM M 7135, with a diameter of 6 mm and a water content of  $w = 7.5\%$  and  $7.3\%$ . The water content and heating value were determined, the averages of the basic chemical data of the anhydrous and ash-free substance were taken from ÖNORM M 7132.

**FUNCTION CHECK** of the temperature controller and the safety temperature limiter/monitor and the system for dissipating surplus heat at the boiler. The measurements were performed according to 5.13 and 5.14 of ÖNORM EN 303-5.

## INTERPRETATION OF EMISSION MEASUREMENTS

In order to evaluate the emissions measurement, the full flue gas analysis was calculated using the carbon monoxide and carbon dioxide contents measured and averaged over the measuring period as well as the composition of the fuel. The speed of the flue gas at the measuring point was calculated from the amount of flue gas, allowing for pressure and temperature.

The content of organic gaseous substances was measured in the damp flue gas, the emission was translated to dry flue gas and displayed as organic carbon. The content of nitrogen oxides was measured in the dry flue gas and displayed as  $\text{NO}_2$ , respectively measured in damp flue gas, translated to dry flue gas and displayed as  $\text{NO}_2$ .

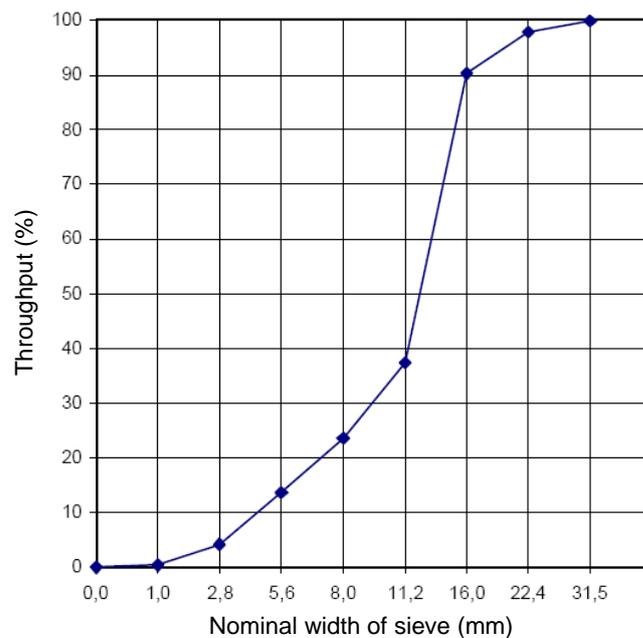
### SIEVE ANALYSIS

Classification according to ÖNORM M 7133

Date of evaluation:	16.Jul. 01
Sieve testing:	Buchmassser
Description of sample:	Chipped spruce wood
Lab Nr:	BLT 01-194
Water content:	28,7 %
Bulk density:	238,5 kg/m <sup>3</sup>
Bulk density in anhydrous state:	170,0 kg/m <sup>3</sup>

### **PARTICLE SIZE (particle size distribution curve)**

Nominal width of sieve	Residue		Passage	
	absolute	relative	absolute	relative
mm	g	%	g	%
31.5	2.0	0.13	1495.0	99.87
22.4	33.0	2.20	1464.0	97.80
16.0	146.0	9.75	1351.0	90.25
11.2	937.0	62.59	560.0	37.41
8.0	1144.0	76.42	353.0	23.58
5.6	1293.0	86.37	204.0	13.63
2.8	1434.0	95.79	63.0	4.21
1.0	1491.0	99.60	6.0	0.40
0.0	1497.0	100.00	0.0	0.00



**Test description**

Test no.: Hkb105  
 Boiler description: Heating boiler for chipped wood, type Turbomatic 110  
 Nominal heat output: 110 kW

**Nominal heat output**

Minimum value Average value Maximum value

**Test conditions**

Start of measuring: 2002-01-10 09:39  
 End of measuring: 2002-01-10 15:39  
 Duration of measuring: 06:00

Ambient temp.: °C 21.1 22.1 23.2  
 Ext. temp.: °C -5.4 -2.2 -1.6  
 Air pressure: mbar 1011

**Fuel, heat input**

Description of fuel Chipped spruce wood  
 Water content kg/kg 0.272  
 Ash content kg/kg 0.004  
 Carbon content kg/kg 0.368  
 Hydrogen content kg/kg 0.045  
 Oxygen content kg/kg 0.311  
 Net calorific value (waterfree) MJ/kg 19.0  
 Calorific value of fuel MJ/kg 13.1  
 Amount of fuel input kg 189.6  
 Hourly amount of fuel kg/h 31.6  
 Heat input kW 115.0

**Heat output, efficiency**

Amount of water input hourly kg/h 4749.2  
 Return temperature °C 53.6 54.7 55.5  
 Flow temperature °C 71.8 73.7 75.9  
 Temperature difference K 17.9 19.1 20.6  
 Heat output kW 105.4  
 Utilisation % 95.8  
 Boiler efficiency % 91.6

**Flue gas measuring**

Exit flue temperature °C 122.4 132.3 143.6  
 draught Pa 9.5 10.2 12.3  
 Carbon dioxide content % 10.3 13.5 15.7  
 Carbon monoxide content ppm 39.9 114.6 1151.4  
 Organic gaseous carbon ppm 0.0 1.2 29.4  
 Nitrogen monoxide ppm 82.2 98.8 108.5

## EMISSIONS MEASUREMENT

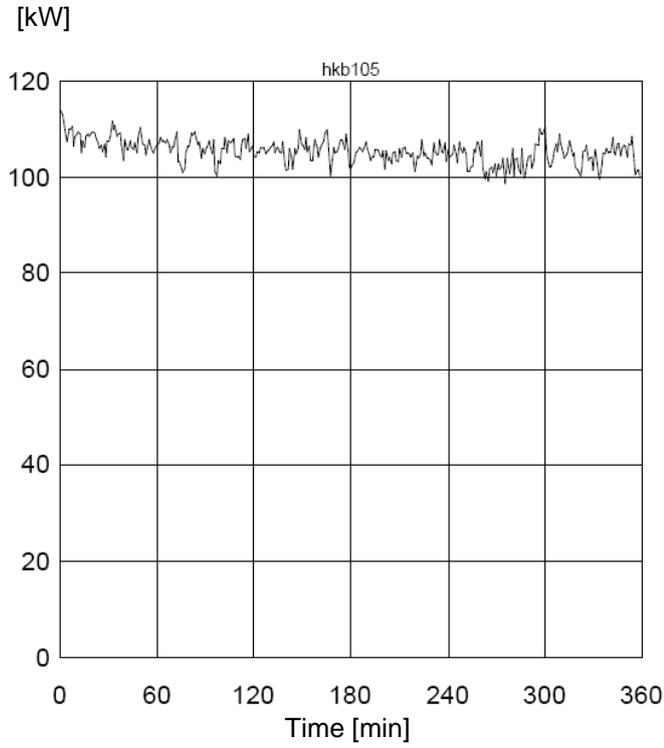
Measurement results for test: hkb105

Start of extraction:	hh:mm	09:45	10:45	11:45	12:45	13:45	14:45
Duration of extraction:	min	30	30	30	30	30	30
CO <sub>2</sub> content (meas.):	%	14.7	14.4	13.9	13.2	12.8	12.2
O <sub>2</sub> content (calc.):	%	5.7	6.0	6.5	7.2	7.7	8.3
Density of gas sample:							
dry gas:	kg/Nm <sup>3</sup>	1.36	1.36	1.36	1.36	1.35	1.35
damp gas:	kg/Nm <sup>3</sup>	1.28	1.28	1.28	1.28	1.28	1.28
Water content:	g/Nm <sup>3</sup>	122.2	120.3	116.7	111.8	108.7	104.2
Speed							
at sampling point: m/s	m/s	2.28	2.32	2.39	2.51	2.58	2.71
at probe head:	m/s	3.27	3.30	3.21	3.21	3.17	3.01
Est. dust	mg	23.8	24.9	23.3	27.0	31.4	33.2
Spec. dust content	mg/Nm <sup>3</sup>	40.0	41.3	39.5	45.8	53.6	59.9

## EVALUATION VALUES

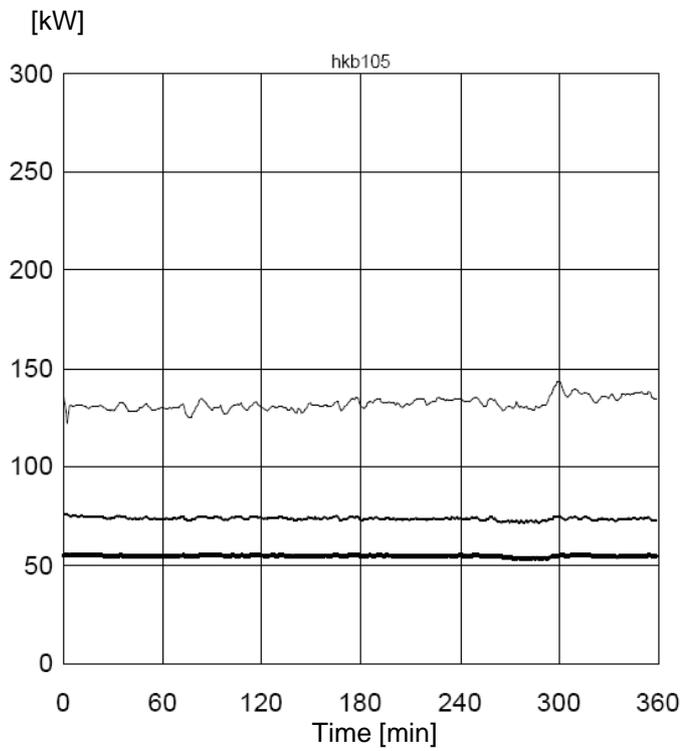
	Based on O <sub>2</sub> content of 13 % mg/Nm <sup>3</sup>	Based on energy input mg/MJ
Dust	27	18
Carbon monoxide (CO)	82	56
Organic carbon (OGC)	1	<1
Nitrogen oxide (NOx)	115	78

### OUTPUT-BASED MEASUREMENTS



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Heat output



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Exit flue temp.

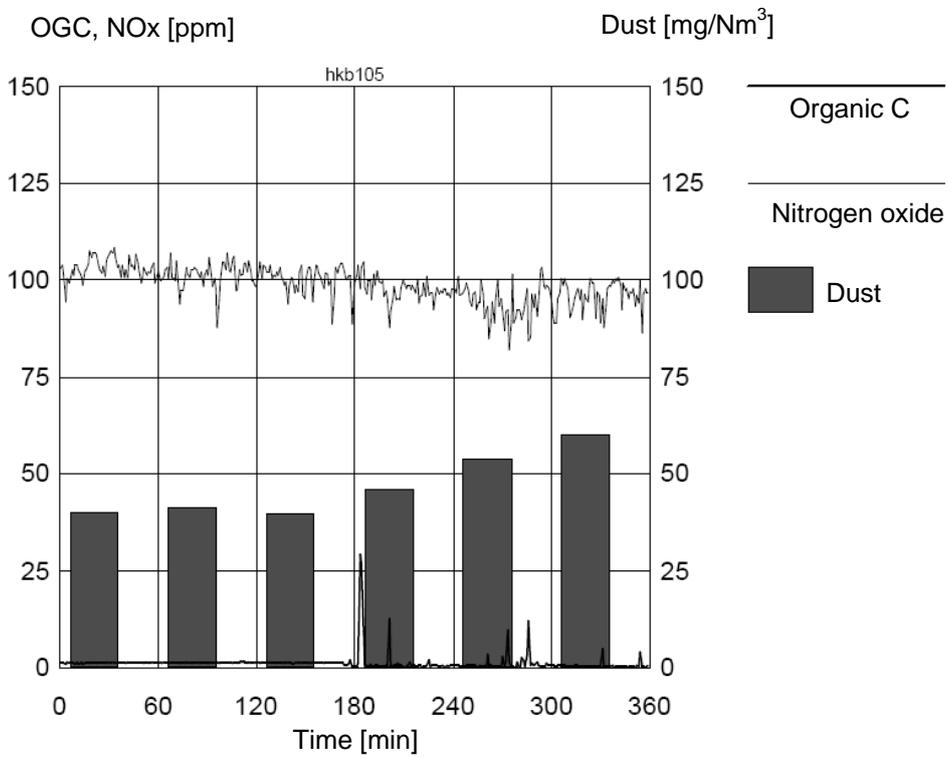
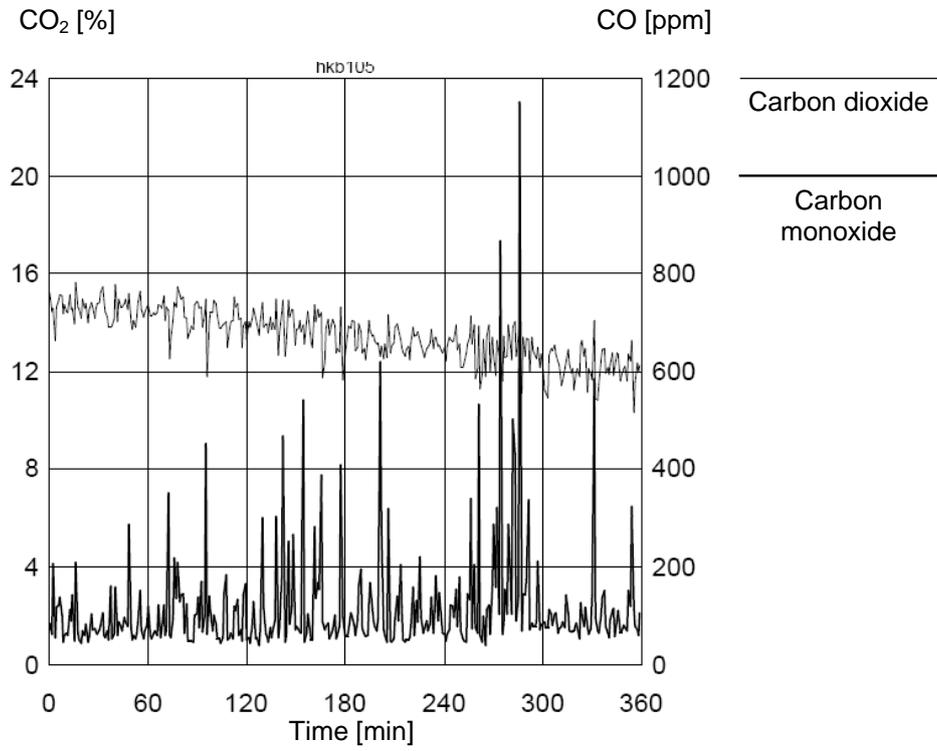
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Flow temp.

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Return temp.

### FLUE GAS COMPOSITION



## Test description

Test no.: Hkb104  
 Boiler description: Heating boiler for chipped wood, type Turbomatic 110  
 Nominal heat output: 110 kW

## Minimum heat output

Minimum value Average value Maximum value

## Test conditions

Start of measuring:		2002-01-09 09:24		
End of measuring:		2002-01-09 15:24		
Duration of measuring:		06:00		
Ambient temp.:	°C	18.7	20.8	21.6
Ext. temp.:	°C	-1.5	-0.1	0.4
Air pressure:	mbar		1011	

## Fuel, heat input

Description of fuel	Chipped spruce wood			
Water content	kg/kg		0.283	
Ash content	kg/kg		0.004	
Carbon content	kg/kg		0.362	
Hydrogen content	kg/kg		0.044	
Oxygen content	kg/kg		0.307	
Net calorific value (waterfree)	MJ/kg		19.0	
Calorific value of fuel	MJ/kg		12.9	
Amount of fuel input	kg		57.5	
Hourly amount of fuel	kg/h		9.6	
Heat input	kW		34.2	

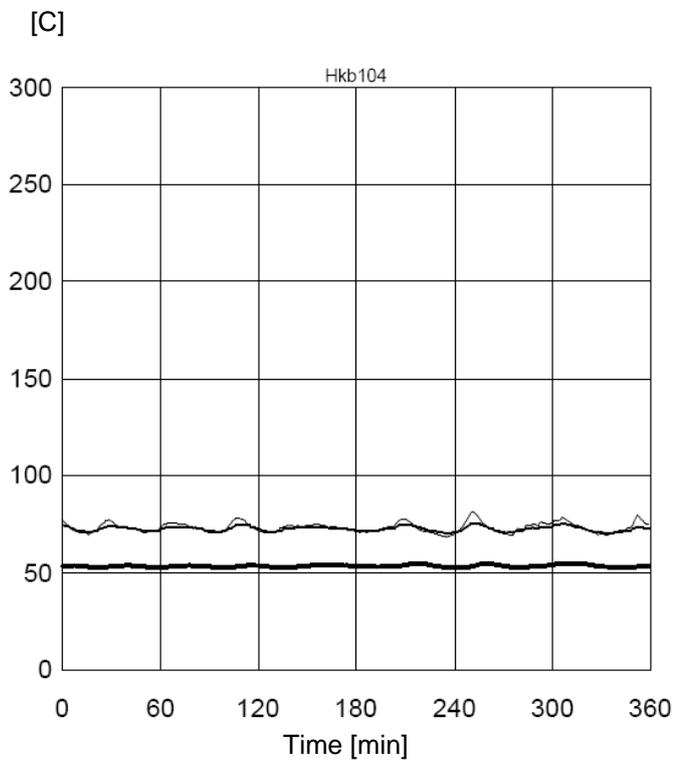
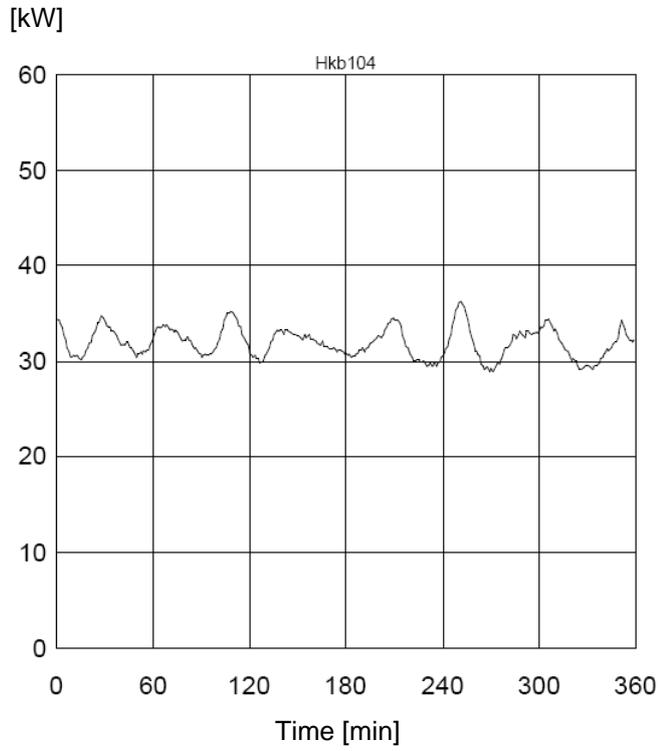
## Heat output, efficiency

Amount of water input hourly	kg/h	1417.3	1428.6	1442.8
Return temperature	°C	52.6	53.5	54.8
Flow temperature	°C	70.5	72.7	75.4
Temperature difference	K	17.3	19.2	21.8
Heat output	kW		31.9	
Utilisation	%		29.0	
Boiler efficiency	%		93.3	

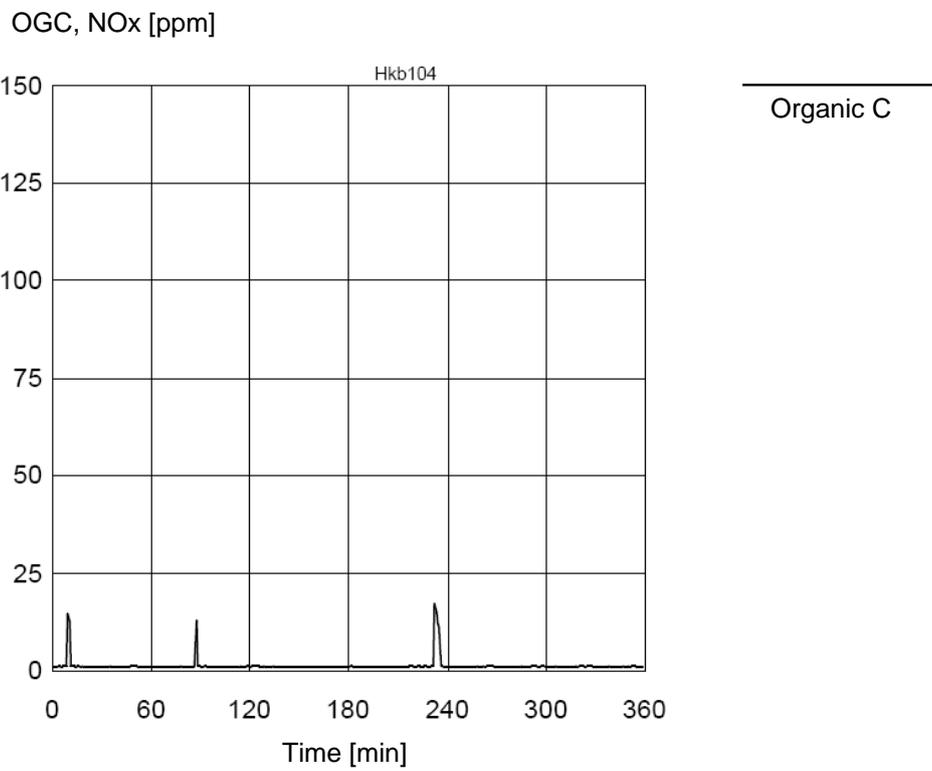
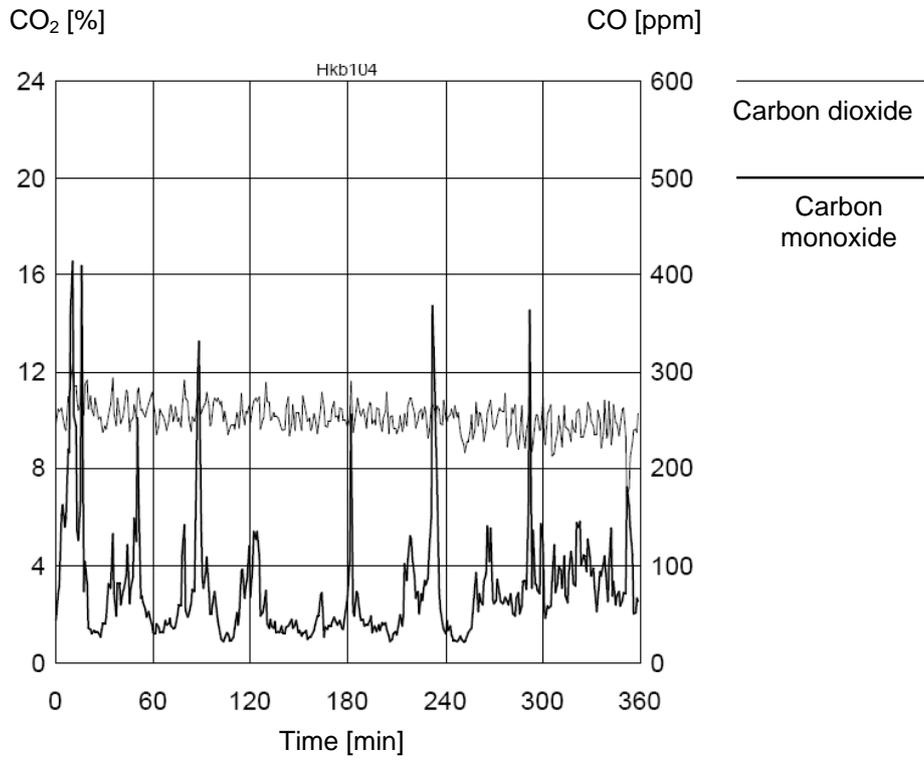
## Flue gas measuring

Exit flue temperature	°C	68,5	73.2	81.3
draught	Pa	7.6	9.1	12.0
Carbon dioxide content	%	6.9	10.1	12.6
Carbon monoxide content	ppm	21.1	76.3	414.4
Organic gaseous carbon	ppm	0.8	1.1	17.2

### OUTPUT-BASED MEASUREMENTS



### FLUE GAS COMPOSITION



## Test description

Test no.:  
Boiler description:  
Nominal heat output:

## Nominal heat output

Hka 622  
Heating boiler for chipped wood, type Turbomatic 110  
110 kW

Minimum value Average value Maximum value

## Test conditions

Start of measuring:  
End of measuring:  
Duration of measuring:

2001-11-14 08:31  
2001-11-14 14:31  
06:00

Ambient temp.:	°C	19.6	21.2	22.3
Ext. temp.:	°C	0.7	2.4	3.8
Air pressure:	mbar		995	

## Fuel, heat input

Description of fuel	Wood pellets			
Water content	kg/kg		0.075	
Ash content	kg/kg		0.002	
Carbon content	kg/kg		0.469	
Hydrogen content	kg/kg		0.057	
Oxygen content	kg/kg		0.397	
Net calorific value (waterfree)	MJ/kg		19.0	
Calorific value of fuel	MJ/kg		17.4	
Amount of fuel input	kg		154.7	
Hourly amount of fuel	kg/h		25.8	
Heat input	kW		124.3	

## Heat output, efficiency

Amount of water input hourly	kg/h		4199.3	
Return temperature	°C	47.2	48.2	49.6
Flow temperature	°C	69.8	71.9	74.6
Temperature difference	K	22.1	23.7	57.7
Heat output	kW		115.8	
Utilisation	%		105.3	
Boiler efficiency	%		93.2	

## Flue gas measuring

Exit flue temperature	°C	123.7	130.2	135.8
draught	Pa	6.1	8.1	11.6
Carbon dioxide content	%	15.4	17.7	19.8
Carbon monoxide content	ppm	3.4	11.0	478.2
Organic gaseous carbon	ppm	0.3	0.4	3.7
Nitrogen monoxide	ppm	70.6	78.9	84.9

## EMISSIONS MEASUREMENT

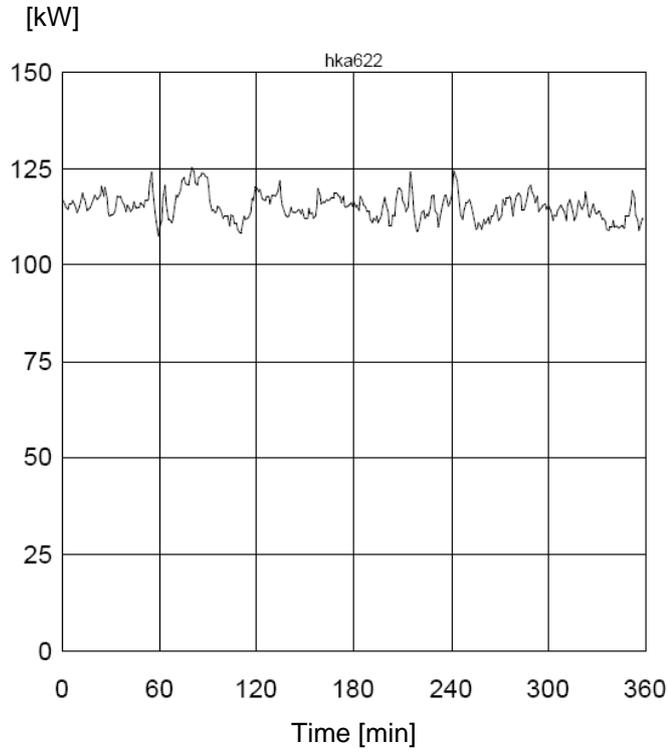
Measurement results for test: HKA622

Start of extraction:	hh:mm	08:35	09:35	10:35	11:35	12:35	13:35
Duration of extraction:	min	30	30	30	30	30	30
CO <sub>2</sub> content (meas.):	%	17.1	17.9	17.6	17.8	17.6	17.9
O <sub>2</sub> content (calc.):	%	3.2	2.4	2.7	2.5	2.7	2.4
Density of gas sample:							
dry gas:	kg/Nm <sup>3</sup>	1.38	1.38	1.38	1.38	1.38	1.38
damp gas:	kg/Nm <sup>3</sup>	1.31	1.31	1.31	1.31	1.31	1.31
Water content:	g/Nm <sup>3</sup>	100.3	104.5	102.8	104.1	102.9	104.4
Speed							
at sampling point: m/s	m/s	2.02	1.94	1.96	1.93	1.95	1.92
at probe head:	m/s	3.21	3.30	3.27	3.23	3.13	3.12
Est. dust	mg	5.5	7.8	7.1	5.8	6.9	6.6
Spec. dust content	mg/Nm <sup>3</sup>	9.3	12.9	11.8	9.7	11.9	11.5

## EVALUATION VALUES

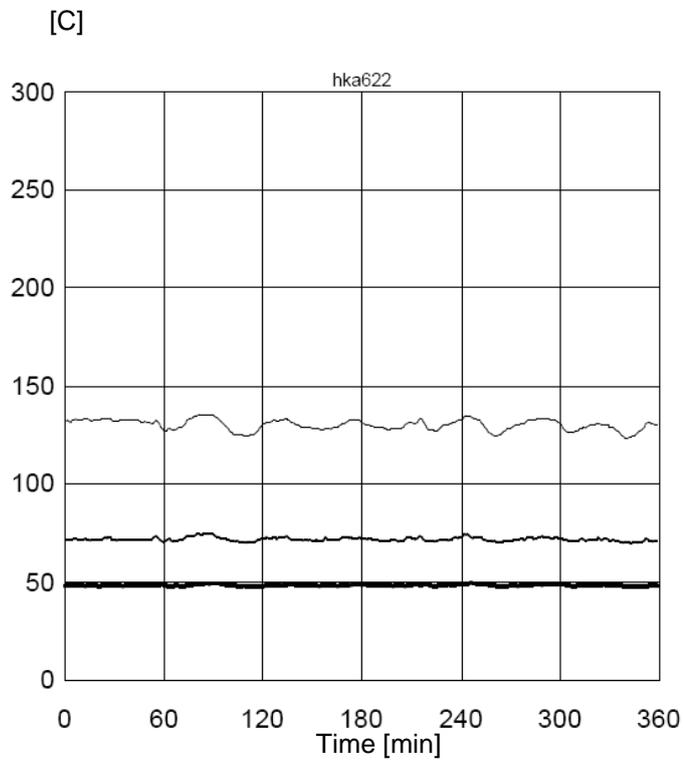
	Based on O <sub>2</sub> content of 13 % mg/Nm <sup>3</sup>	Based on energy input mg/MJ
Dust	5	3
Carbon monoxide (CO)	6	4
Organic carbon (OGC)	<1	<1
Nitrogen oxide (NOx)	81	53

### OUTPUT-BASED MEASUREMENTS



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Heat  
output



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Exit flue temp.

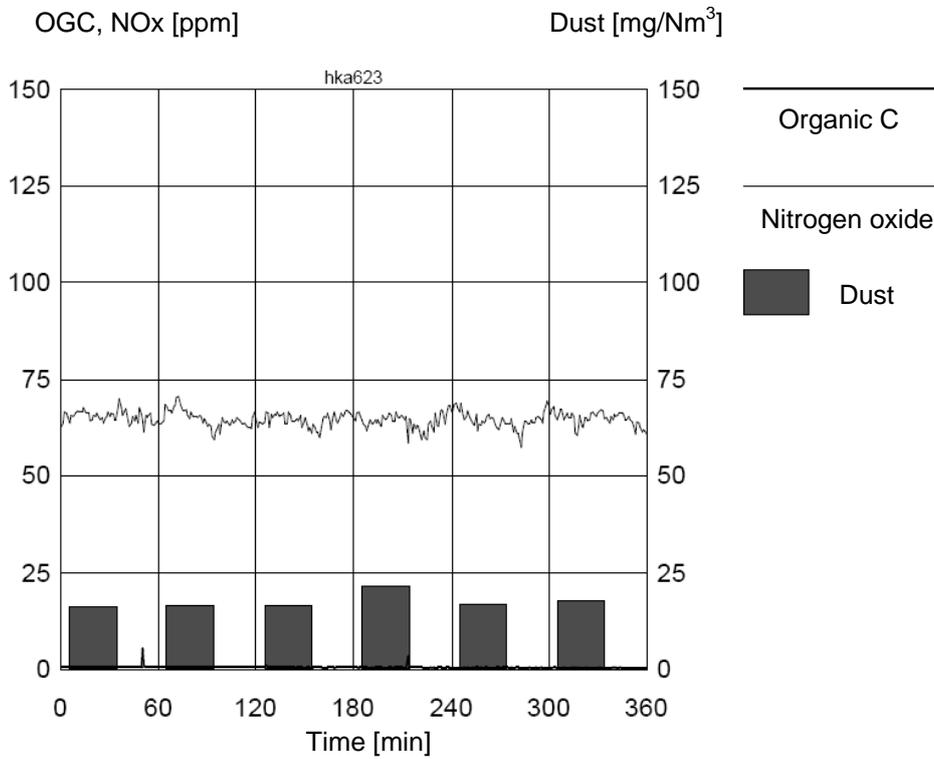
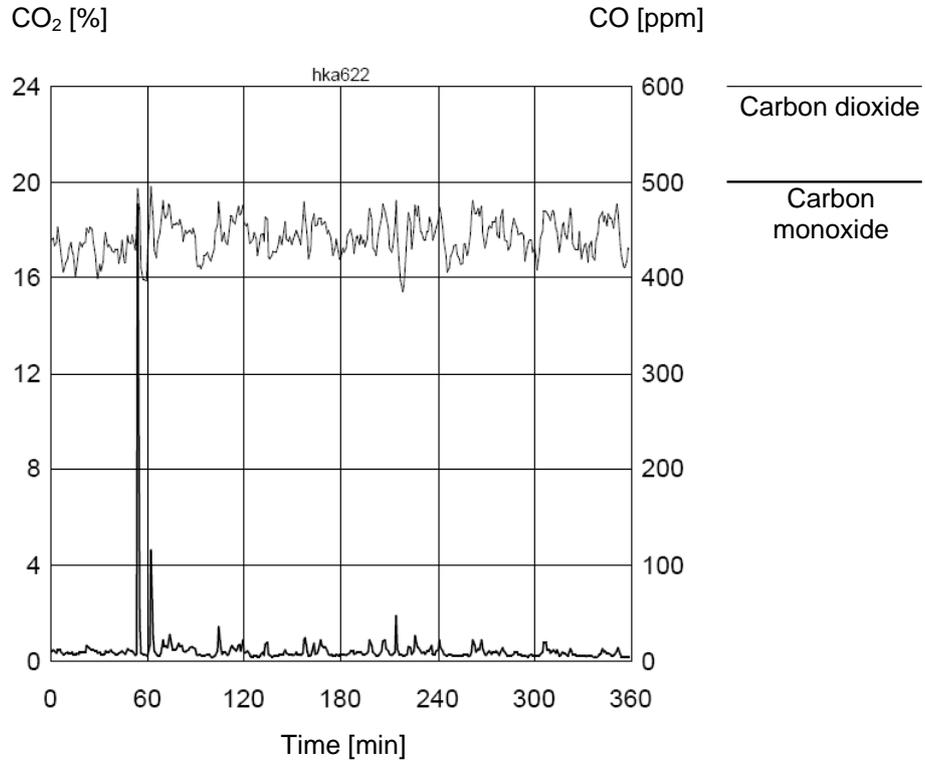
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Flow temp.

---

Return temp.

### FLUE GAS COMPOSITION



## Test description

Test no.: Hka621  
 Boiler description: Heating boiler for chipped wood, type Turbomatic 110  
 Nominal heat output: 110 kW

## Minimum heat output

Minimum value Average value Maximum value

## Test conditions

Start of measuring:		2001-11-13 09:15		
End of measuring:		2000-11-13 15:15		
Duration of measuring:		06:00		
Ambient temp.:	°C	19.1	19.6	19.8
Ext. temp.:	°C	0.9	1.3	1.9
Air pressure:	mbar		984	

## Fuel, heat input

Description of fuel	Wood pellets			
Water content	kg/kg		0.076	
Ash content	kg/kg		0.002	
Carbon content	kg/kg		0.468	
Hydrogen content	kg/kg		0.057	
Oxygen content	kg/kg		0.396	
Net calorific value (waterfree)	MJ/kg		19.0	
Calorific value of fuel	MJ/kg		17.3	
Amount of fuel input	kg		45.0	
Hourly amount of fuel	kg/h		7.5	
Heat input	kW		36.1	

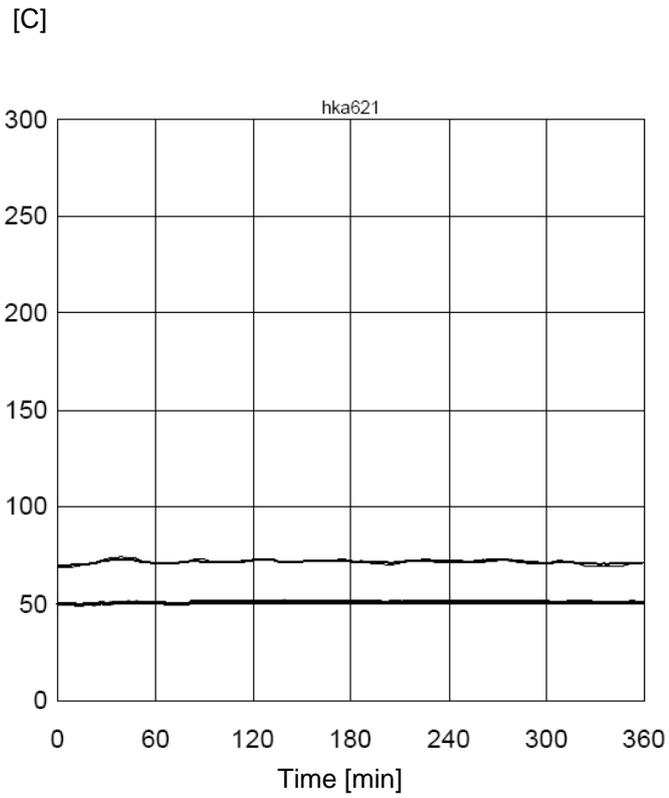
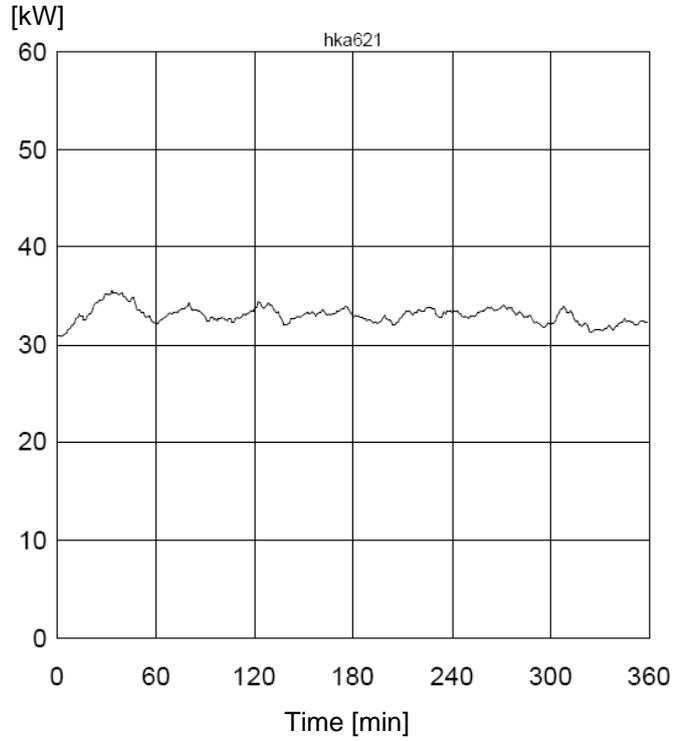
## Heat output, efficiency

Amount of water input hourly	kg/h	1341.5	1347.1	1351.2
Return temperature	°C	49.3	50.8	51.5
Flow temperature	°C	69.3	71.9	73.0
Temperature difference	K	19.7	21.1	22.7
Heat output	kW		33.2	
Utilisation	%		30.2	
Boiler efficiency	%		91.9	

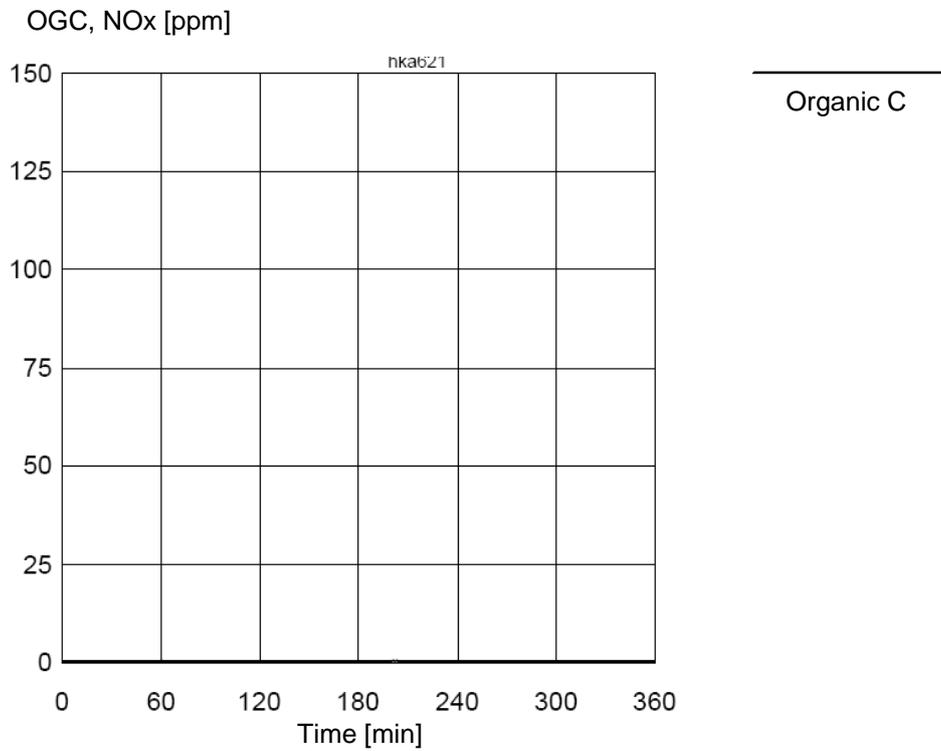
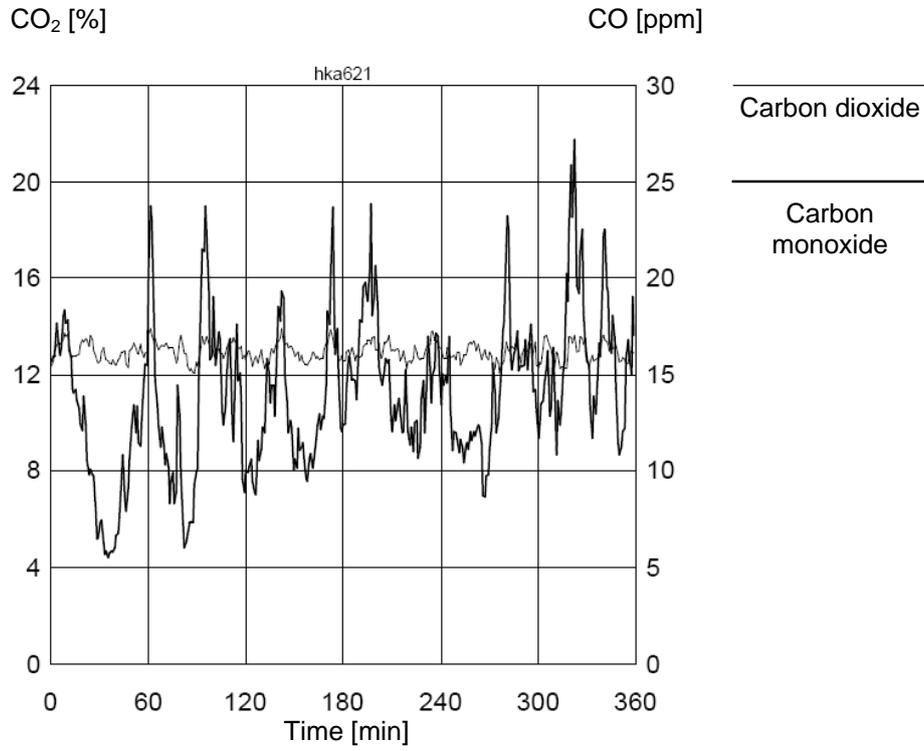
## Flue gas measuring

Exit flue temperature	°C	68.9	71.3	74.2
draught	Pa	5.6	6.7	9.7
Carbon dioxide content	%	12.1	13.0	13.9
Carbon monoxide content	ppm	5.5	14.0	27.2
Organic gaseous carbon	ppm	0.2	0.3	0.6

### OUTPUT-BASED MEASUREMENTS



### FLUE GAS COMPOSITION



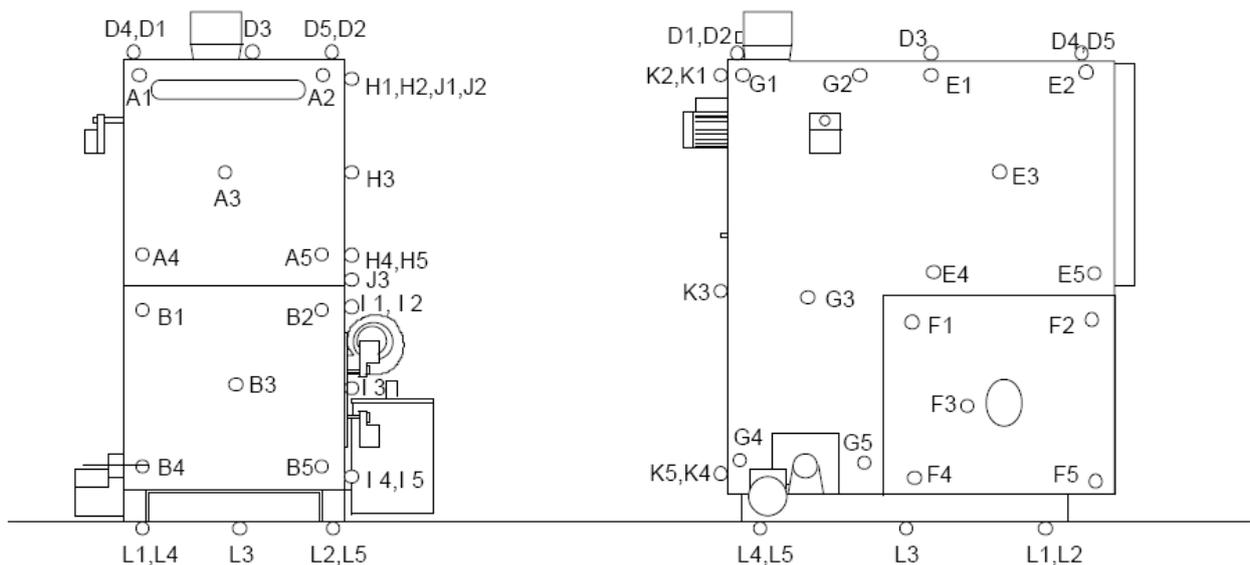
## SURFACE LOSSES

The determination of heat losses through radiation of the boiler surface was conducted according to DIN 4702-2 by using radiation coefficients and their arrangement (according to Nusselt). A test in the nominal heat output range involved taking temperature readings at 63 points on the surface of the boiler and calculating the surface losses according to DIN 4702-2. The results of these measurements are shown in the table below:

Test number:	HKB105
Ambient temperature:	22 °C
Flow temperature:	73 °C
Exit flue temperature:	135 °C
Nominal heat output of boiler:	105.4 kW
Losses due to radiant heat by the boiler:	0.72 kW
Loss of nominal heat output in percent:	0.7 %

Measuring point	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1
Temperature [°C]	35	32	27	26	25	28	28	30	28	32	46
Measuring point	C2	C3	C4	D1	D2	D3	D4	D5	E1	E2	E3
Temperature [°C]	36	47	33	32	34	30	38	39	29	31	27
Measuring point	E4	E5	F1	F2	F3	F4	F5	G1	G2	G3	G4
Temperature [°C]	32	29	40	38	38	45	42	28	30	26	26
Measuring point	G5	H1	H2	H3	H4	H5	I1	I2	I3	I4	I5
Temperature [°C]	31	34	30	28	30	39	31	32	31	39	34
Measuring point	J1	J2	J3	J4	J5	K1	K2	K3	K4	K5	L1
Temperature [°C]	30	30	28	30	28	35	33	28	28	27	26
Measuring point	L2	L3	L4	L5	M1	M2	M3	M4			
Temperature [°C]	33	29	26	26	54	39	39	50			

The surface temperature of the operating handle for the heat exchanger cleaning system was 2 K above the ambient temperature.



### **FUNCTION CHECK OF TEMPERATURE CONTROLLER and SAFETY TEMPERATURE LIMITER ON BOILER**

In order to check the functioning of the temperature controller, the boiler was fired with wood pellets and operated at the nominal heat output. The heat consumption was reduced to 40 % at a flow temperature of 72.5 °C. After 9 minutes at a flow temperature of 90.9 °C the burn back flap is shut and the stoker channel is emptied. The maximum flow temperature of 95.8 °C was reached after another 7 minutes.

In order to check the functioning of the safety temperature limiter, the boiler was operated at the nominal heat output. The heat consumption was reduced to 40 % at a flow temperature of 70.7 °C. The temperature controller was disabled. After 7 minutes the safety temperature limiter switched the heating off at a temperature of 102.9 °C. The maximum flow temperature was reached at 104.0 °C one minute later.

### **FUNCTION CHECK OF SYSTEM FOR DISSIPATING SURPLUS HEAT**

The boiler was operated at the nominal heat output in accordance with ÖNORM EN 303-5 and no heat was discharged to the system as per point 5.14. At the beginning of the test the flow temperature was 70.1 °C; after 4 minutes, at 92 °C the safety temperature limiter switched the heating off. One minute later at 99.2 °C the thermostatic valve of the thermal discharge safety device opens. The maximum boiler temperature of 109.1 °C was reached after a further 8 minutes, thus meeting the requirements.

Whilst the functioning of the temperature controller/safety temperature limiter and the system for dissipating surplus heat were being checked, the CO content and CO<sub>2</sub> content in the flue gas were measured. The maximum measurement registered was 3.5 % CO with a CO<sub>2</sub> content of 12.1 %.

### **ELECTRICAL POWER CONSUMPTION**

	P [W]
Stoker screw	589
Discharge screw	392
Ash discharge screw heat exchanger	222
Ash discharge screw combustion chamber	214
Shaker motor	28
Induced draught fan	139
Combustion air blower fan (primary/secondary)	66
Ignition fan	1479

Over a test period of 364 minutes at the nominal heat output with chipped spruce wood, 3100 Wh was consumed, which equals 0.5 % of the nominal heat output.

## SUMMARY

The heating boiler for chipped wood, type Turbomatic 110 manufactured by Fröling Heizkessel- und Behälterbau GmbH was tested with the fuels chipped spruce wood (31.9 kW - 105.4 kW) and wood pellets (33.2 kW - 120.2 kW) within the specified heat output range.

As the boiler is operated in the nominal heat output range with an exit flue temperature of less than 160 K above room temperature, ÖNORM EN 303-5 stipulates that the manufacturer must specify the design of the flue gas system (chimney) to prevent possible damage by seepage, insufficient feed pressure and condensation.

The measurements produced the following results:

Output	Exit flue temperature	Efficiency (direct)	Carbon dioxide	Carbon monoxide	Organic carbon	Nitrogen oxide	Dust
[kW]	[°C]	[%]	[%]	[mg/MJ]	[mg/MJ]	[mg/MJ]	[mg/MJ]
<b>Nominal heat output: chipped spruce wood w = 27.2 %</b>							
105.4	132.3	91.6	13.5	56	<1	78	18
<b>Minimum heat output: chipped spruce wood w = 28.3 %</b>							
31.9	73.2	93.3	10.1	49	1	not measured	not measured
<b>Nominal heat output: wood pellets w = 7.5 %</b>							
115.8	130.2	93.2	17.7	4	<1	53	3
<b>Minimum heat output: wood pellets w = 7.6 %</b>							
33.2	71.3	91.9	13.0	7	<1	not measured	not measured

Emissions in mg/MJ (based on the energy used)

Output	Exit flue temperature	Efficiency (direct)	Carbon dioxide	Carbon monoxide	Organic carbon	Nitrogen oxide	Dust
[kW]	[°C]	[%]	[%]	[mg/m <sup>3</sup> ]	[mg/ m <sup>3</sup> ]	[mg/ m <sup>3</sup> ]	[mg/ m <sup>3</sup> ]
<b>Nominal heat output: chipped spruce wood w = 27.2 %</b>							
105.4	132.3	91.6	13.5	82	1	115	27
<b>Minimum heat output: chipped spruce wood w = 28.3 %</b>							
31.9	73.2	93.3	10.1	73	2	not measured	not measured
<b>Nominal heat output: wood pellets w = 7.5 %</b>							
115.8	130.2	93.2	17.7	6	<1	81	5
<b>Minimum heat output: wood pellets w = 7.6 %</b>							
33.2	71.3	91.9	13.0	10	<1	not measured	not measured

Emissions in mg/m<sup>3</sup> (based on 13 % O<sub>2</sub>)

On the basis of the test results the heating boiler, type Turbomatic 110 for chipped wood manufactured by Fröling Heizkessel- und Behälterbau GmbH may display the quality mark of the HBLFA Francisco Josephinum, BLT – Biomass - Logistics - Technology .

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