Strojírenský zkušební ústav, s.p.
(Engineering Test Institute, Public Enterprise)
Hudcova 424/56b, 621 00 Brno, Czech Republic

TEST REPORT
32-0240/T

Product:	Hot-water boiler for solid fuel (wood - A) with manual fuel supply
Type designation:	VG
Versions:	VG 80, VG 100
Customer:	Arikazan a.s. Büyükelçi sok. No:9 Kavaklidere Ankara Turkey
Manufacturer:	Arikazan a.s. Büyükelçi sok. No:9 Kavaklidere Ankara Turkey
Person responsible for review and evaluation:	Ing. Stanislav Buchta
Report issue date:	2015-01-26
Distribution list:	1 copy to the Engineering Test Institute 1 copy to the Customer

The tests were conducted on the basis of Order X-54326 dated 2016-10-23 (received on 2016-10-26), Contract X-54326/32.

I. Product description, intended use and mode of application

The steel hot-water boiler with manual fuel supply, type VG, is designed for the burning of wood on the principle of downward burning with pyrolisis combustion. The boiler serves for the production of heating water. The boiler body is made of welded steel components. The charging chamber is situated in the upper part of the boiler body, and the combustion chamber with ceramic lining is situated in the bottom part. The charging chamber is separated from the combustion chamber with a wall in which a ceramic nozzle is mounted with integrated holes for the secondary combustion air supply. The boiler shell consists of coated steel plates lined with mineral wool.
The exhaust branch with a horizontal axis is situated in the rear side of the boiler.
There is a control panel in the upper part of the boiler with an electronic regulation guaranteeing the control and safety functions, including the indication of the water temperature in the boiler.

II. Sample tested

Boiler output versions that are the subject of the proceedings:

Boiler heat output version	Heat output	Place of testing
VG 80	80 kW	Arıkazan A.S, Konya yolu 26. Km. Golbası, Ankara, Turkey
VG 100	100 kW	

Visual inspection, testing and evaluation were carried out by Ing. Michal Havlů, Test Engineer, at Arıkazan A.S, Konya yolu 26. Km. Golbasi, Ankara, Turkey, in 12/2015.

The tests were performed with the measurement and test equipment with valid calibration.

III. Measuring and testing equipment

No.	Description	Inventory number	Calibration valid until	Accuracy
1.	Combustion product analyser, Horiba, type 680 P	92-0004	Calibration prior to each measurement	see CRM 103000237769 see CRM 103000237770
2.	Weighing machine	02-2290	02/2017	see Calibration Sheet 6051-KL-H-0651-10
3.	Water meter, NW 20	02-1575	03/2017	see Calibration Sheet AKL-P/006/2009
4.	Data collection system	02-2241	12/2016	see Calibration Sheet 110002
5.	Moisture meter, thermometer	11-6258	11/2016	see Calibration Sheet 7630F/09
6.	Barometer	11-2541	01/2019	see Calibration Sheet 613-KL-K011-08
7.	Draught gauge	11-7275	02/2017	see Calibration Sheet 0144F/11
8.	Stop watch	99-0760	10/2017	see Calibration Sheet 2850E-07
9.	Calorimeter, IKA, type C 5000	02-2236	03/2017	± 0.12 MJ/kg
10.	Elemental analyser, Perkin Elmer, type 2400 CHNS	02-2107	03/2017	± 0.2 % rel.
11.	Gravimat, SHC 501	02-2328	04/2018	see Calibration Sheet 090177 (8,9), 090180
12.	Laboratory weighing machine	02-1458	06/2017	see Calibration Sheet 6051-KL-H376-09
13.	Weighing machine, Ohaus MB 45	02-2274	06/2017	see Calibration Sheet 6051-KL-H374-09
14.	Manometer	11-1985	06/2017	see Calibration Sheet 090162
15.	Prandtl tube, 0.3 m	ME 484	11/2016	see Calibration Sheet 5012-KL-RS090-09
16.	Psychrometer H 4220	92-0005	12/2016	see Calibration Sheet 090176

Note: * Calibrated prior to each measurement, with the use of certified reference material

IV. Results of tests and evaluation

No.	Requirement	Technical standard, regulation applied	Source materials	Evaluation	
				Test	Evaluation
7.	**Pressurized component tightness and strength test (1001.1*)**	ČSN EN 303-5:2013 Art. 5.4, 5.4.1, 5.4.2	Page 6	+	
8.	**Surface temperature test (1003*)**	ČSN EN 303-5:2013 Art. 5.12, 4.3.6	Pages 7- 8	+	
9.	**Test of heat output, input and efficiency(1004.1*)** **Test of combustion product temperature (1004.2*)**	ČSN EN 303-5:2013 Art. 4.4.2, 5.7, 5.8, 5.9, 5.10 ČSN EN 303-5:2013 Art. 4.4.3	Pages 9 - 13	+	
10.	**Combustion efficiency test – emissions (1005.1*)**	ČSN EN 303-5:2013, Art. 4.4.7, 5.7.3, 5.7.4, 5.9, 5.10.4	Pages 14 – 15	+	
11.	**Test of heat output, input and efficiency (1004.1*)** **Combustion efficiency test – emissions (1005.1*)**	ČSN EN 303-5:2013, Annex C, Deviations from Austria, C.2.2, C.2.3	Pages 16 – 17	+	
		ČSN EN 303-5:2013, Annex C, C.3 Deviations from Croatia	-	0	
		ČSN EN 303-5:2013, Annex C, Deviations from Denmark, C.4.1, C.4.2	Pages 18 – 19	+	
		ČSN EN 303-5:2013, Annex C, Deviations from Germany, C.5.1, C.5.2	Pages 20 – 21	+	
		ČSN EN 303-5:2013, Annex C, C.6 Deviations from Switzerland	Pages 22 - 23	+	

No.	Requirement	Technical standard, regulation applied	Source materials	Evaluation	
				Test	Evaluation
12.	**Test of heat output, input and efficiency (1004.1*)** **Combustion efficiency test – emissions (1005.1*)**	ČSN EN 303-5:2013 Annex C, C.8 Deviations from Italy	Page 24	+	0
13.	**Test of control, regulation and safety elements (1006.1*)** **Combustion efficiency test – emissions (1005.1*)** **Test of device for dissipating excess heat 1006.2***	ČSN EN 303-5:2013 Art. 5.13, 5.15, 5.16.3, 4.1 ČSN EN 303-5:2013 Art. 5.9, 5.10.4	Pages 25 – 28	+	0

Note:
No.: 1 - 6
(**) Not a test

Evaluation:
+ Requirement fulfilled
- Requirement not fulfilled
x Not assessed
0 Not applicable

Accredited test number: **1001.1*** Test title: **Pressurized component tightness and strength test**

Test method: ČSN EN 303-5:2013 Art. 5.4, 5.4.1, 5.4.2

Sample tested: VG 80, VG 100

Measuring equipment used: Chapter III - Measuring and test equipment

Test results:

Requirement	Requirement specification	Test evaluation	Note
Pressure test for boilers of sheet or sheet metal of non-ferrous metal	ČSN EN 303-5:2013 Art. 5.4		
Tests to be carried out before production The type test pressure is 2 × *PS* using hydraulic pressure where *PS* is the maximum permissible operating pressure. The test period shall be at least 10 min and if it is to apply to a 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 test. A record shall be made of the test, including the following details: - exact description of the boiler tested by 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 report shall be signed by, as a minimum, the works tester responsible and one witness.	ČSN EN 303-5:2013 Art. 5.4.1	+ + + + + +	Enclosed technical documentation.
Test during production Each boiler shall be tested during the production and the test pressure shall be at least 1.43 × *PS*.	ČSN EN 303-5:2013 Art. 5.4.2	+	

Test evaluation: No leakages or visible permanent deformations appeared during the test.

Accredited test number: **1003*** Test title: **Surface temperature test**

Test method: ČSN EN 303-5:2013 Art. 5.12, 4.3.6

Sample tested: VG 80, VG 100

Measuring equipment used: Chapter III - Measuring and test equipment

Test results:

Requirement	Requirement specification	Test evaluation	Note
Surface temperature The mean surface temperature shall be measured at nominal heat output. In order to do this, a minimum of 5 points on each boiler surface shall be measured. Under the same conditions, the critical temperatures (e.g. boiler doors, operating levers) shall be measured.	ČSN EN 303-5:2013 Art. 5.12	+	
The surface temperature on the outside of the boiler (including the bottom and doors but not including the flue gas outlet and maintenance openings of natural draft boilers) shall not exceed the room temperature by more than 60 K when tested in accordance with 5.12. The requirement for the bottom is not applicable for instances when the manufacturer declares that the boiler is to be installed on a non-combustible base. When tested in accordance with 5.12, the surface temperature of operating levers and all parts which shall be touched by hand during operation of the boiler shall not exceed the room temperature by more than the following values: - 35 K for metals and similar materials; - 45 K for porcelain and similar materials; - 60 K for plastics and similar materials.	ČSN EN 303-5:2013 Art. 4.3.6	+	

Measurement results: VG 80

Average temperatures of boiler walls, doors and covers (^{0}C):	
Fuel type	Wood – A
Front wall	29.4
Rear wall	24.0
Right wall	20.6
Left wall	24,8
Upper wall	30.4
Lower wall (a base was used, non-combustible material)	50.0
Temperatures of control elements (^{0}C):	
El. control panel – plastic	25.0

Measurement results: VG 100

Average temperatures of boiler walls, doors and covers (^{0}C):	
Fuel type	Wood – A
Front wall	34.3
Rear wall	27.4
Right wall	23.9
Left wall	27.2
Upper wall	30.4
Lower wall (a base was used, non-combustible material)	50.0
Temperatures of control elements (^{0}C):	
El. control panel – plastic	26.0

Measurement uncertainty: 2 ^{0}C for temperatures within the range of (0 ÷ 250)^{0}C

"The above-specified extended measurement uncertainties are calculated as a factor of the measurement uncertainty and the extension coefficient, k=2, corresponding to the coverage certainty of 95% as regards standard classification. The uncertainties do not reflect the impact of sample taking and lack of homogeneity. The standard uncertainty was determined in accordance with Document EA 4-02."

Test evaluation: The specified temperature rise values have not been exceeded.

Accredited test number:	**1004.1*** Test title: **1004.2***	**Test of heat output, input and efficiency** **Test of combustion product temperature**

Test method:	ČSN EN 303-5:2013 Art. 4.4.2, 4.4.3, 5.7 to 5.10
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

Average measured and calculated values (solid fuels):

Test period:		I.	II.
Boiler type:		VG 80	
Output tested:		Nominal	Nominal
Fuel type:		**Wood - A**	
Combustion period, (manual) stoking		Minimally 2 × 2 hours	
Nominal heat output (specified by manufacturer)	[kW]	80	80
Flue gas temperature	[°C]	143.5	140.3
Fuel mass added	[kg/h]	20.12	19.04
Inlet water temperature	[°C]	55.7	54.1
Outlet water temperature	[°C]	76.3	73.8
Cooling water temperature	[°C]	0.0	0.0
Cooling water flow rate	[m3/h]	3.2419	3.2064
Draught	[Pa]	20.0	20.0
Ambient temperature	[°C]	14.0	14.0
Relative air humidity	[%]	36.0	35.0
Barometric pressure	[kPa]	99.1	99.1

Analysis of combustion products:

Test (period of burning) :		I.	II.
Oxygen, O_2	[%]	7.98	8.67
Carbon dioxide, CO_2	[%]	11.52	10.97
Carbon monoxide, CO	[ppm]	1224	949
Higher hydrocarbons, THC-OGC	[ppm]	11	4
Nitrogen oxides NOx	[ppm]	80	103

Auxiliary combustion values (solid fuels):

Test (period of burning) :		I.	II.
Stoichiometric oxygen volume	[m3/kg]	0.895	0.895
Stoichiometric air volume	[m3/kg]	4.261	4.261
Stoichiometric volume of dry combustion products	[m3/kg]	4.156	4.156
Maximum content of CO_2	[%]	18.98	18.98
Stoichiometric air multiple	[-]	1.59	1.68
Volume of dry combustion products, actual	[m3/kg]	6.776	7.134
Content of H_2O in combustion air	[m3/kg]	0.040	0.041
Content of H_2O in combustion products	[m3/kg]	0.926	0.927

Calculated values - thermal overview

Test (period of burning) :		I.	II.
Loss of sensible heat of combustion products	[%]	8.8	9.0
Loss of gas underburning	[%]	0.7	0.5
Loss of mechanical underburning	[%]	0.3	0.3
Loss of heat transfer into environment	[%]	0.9	1.0
Total loss	[%]	10.7	10.8
Fuel mass added - actual	[kg/h]	20.372	19.279
Heat input	[kW]	87.9	83.2
Heat output	**[kW]**	**78.1**	**73.7**
Uncertainty of determining heat output	[kW]	3.3	3.1
Efficiency – direct method	**[%]**	**88.8**	**88.6**
Output / nominal output	[%]	97.6	92.2

At nominal output, when burning **Wood – A,** the boiler efficiency meets the requirements applicable to **Class 5** as per ČSN EN 303-5:2013, Fig. 1.

Test evaluation:

The measured heat output is within the ± 8% tolerance;
Boiler Class 5;
At nominal output, combustion product temperature is less than 160 K above the ambient temperature;
When burning Wood – A, the period of burning is more than 2 hours;

Electric consumption

Maximum electrical input	80 W
Electrical input at nominal heat output	75 W
Electrical input for STAND BY mode	3 W

Test results:

Average measured and calculated values (solid fuels):

Test period:		I.	II.
Boiler type:		VG 100	
Output tested:		Nominal	Nominal
Fuel type:		**Wood - A**	
Combustion period, (manual) stoking		Minimally 2 × 2 hours	
Nominal heat output (specified by manufacturer)	[kW]	100	100
Flue gas temperature	[°C]	134.6	138.6
Fuel mass added	[kg/h]	27.48	26.15
Inlet water temperature	[°C]	53.7	56.4
Outlet water temperature	[°C]	75.0	77.0
Cooling water temperature	[°C]	0.0	0.0
Cooling water flow rate	[m3/h]	4.3762	4.2935
Draught	[Pa]	20	20
Ambient temperature	[°C]	15	15
Relative air humidity	[%]	39.0	37.0
Barometric pressure	[kPa]	99.458	99.458

Analysis of combustion products:

Test (period of burning) :		I.	II.
Oxygen, O_2	[%]	6.74	6.88
Carbon dioxide, CO_2	[%]	12.60	12.59
Carbon monoxide, CO	[ppm]	1189	1263
Higher hydrocarbons, THC-OGC	[ppm]	8	6
Nitrogen oxides NOx	[ppm]	133	120

Auxiliary combustion values (solid fuels):

Test (period of burning) :		I.	II.
Stoichiometric oxygen volume	[m3/kg]	0.895	0.895
Stoichiometric air volume	[m3/kg]	4.261	4.261
Stoichiometric volume of dry combustion products	[m3/kg]	4.156	4.156
Maximum content of CO_2	[%]	18.98	18.98
Stoichiometric air multiple	[-]	1.46	1.47
Volume of dry combustion products, actual	[m3/kg]	6.204	6.205
Content of H_2O in combustion air	[m3/kg]	0.042	0.040
Content of H_2O in combustion products	[m3/kg]	0.928	0.927

Calculated values - thermal overview

Test (period of burning) :		I.	II.
Loss of sensible heat of combustion products	[%]	7.6	7.8
Loss of gas underburning	[%]	0.6	0.6
Loss of mechanical underburning	[%]	0.3	0.3
Loss of heat transfer into environment	[%]	0.8	0.8
Total loss	[%]	9.3	9.6
Fuel mass added - actual	[kg/h]	27.825	26.478
Heat input	[kW]	120.1	114.3
Heat output	**[kW]**	**108.3**	**102.9**
Uncertainty of determining heat output	[kW]	4.6	4.3
Efficiency – direct method	**[%]**	**90.2**	**90.1**
Output / nominal output	[%]	108.3	102.9

At nominal output, when burning **Wood – A,** the boiler efficiency meets the requirements applicable to **Class 5** as per ČSN EN 303-5:2013, Fig. 1.

Test evaluation:

The measured heat output is within the ± 8% tolerance;
Boiler Class 5;
At nominal output, combustion product temperature is less than 160 K above the ambient temperature;
When burning Wood – A, the period of burning is more than 2 hours;

Electric consumption

Maximum electrical input	120 W
Electrical input at nominal heat output	115 W
Electrical input for STAND BY mode	3 W

Fuel analysis

Fuel type	Wood – A			
Analytical indicator	Symbol	Unit	Value	Uncertainty
Heat of combustion	Q_s	[MJ/kg]	18.48	0.14
Caloric value	Q_j	[MJ/kg]	17.01	0.14
All water in original condition	W^r_t	[% by weight]	19.98	0.03
Ash	A	[% by weight]	0.73	0.03
Carbon	C	[% by weight]	37.77	0.25
Hydrogen	H	[% by weight]	4.56	0.10
Nitrogen	N	[% by weight]	0.10	0.10
Sulphur	S	[% by weight]	0.005	0.003
Chlorine	Cl	[% by weight]	0.004	0.002
Oxygen – calculation for 100%	O	[% by weight]	36.74	
Conversion factor f_{emis} for emissions in [mg/m3] to [mg/MJ]	f_{emis}	[-]	0.27056	

Note: Sample in original condition

Measurement uncertainty: Specified in Measurement results

"The above-specified extended measurement uncertainties are calculated as a factor of the measurement uncertainty and the extension coefficient, k=2, corresponding to the coverage certainty of 95% for standard classification. The uncertainties do not reflect the impact of sample taking and lack of homogeneity. The standard uncertainty was determined in accordance with Document EA 4-02".

Accredited test number: **1005.1*** Test title: **Combustion efficiency test - emissions**

Test method: ČSN EN 303-5:2013
Art. 4.4.7, 5.7.3, 5.7.4, 5.9, 5.10.4

Sample tested: VG 80, VG 100

Measuring equipment used: Chapter III - Measuring and test equipment

Requirement	Requirement specification	Test evaluation	Note
Emission limits Combustion shall be of low-emission. This requirement shall be satisfied if the emission values shown in Table 6 are not exceeded when operating at nominal heat output or, in the case of boilers with heat output range, when operating at nominal heat output and minimum heat output, in accordance with 5.7, 5.9 and 5.10.	ČSN EN 303-5:2013 Art. 4.4.7	+	

Table 6

Stoking	Fuel	Nominal heat output	Emission limits								
			CO			OGC/THC			Dust		
			mg-m^3 at 10% O_2								
		kW	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5
Manual	Biogenic	≤ 50	5000	1200	700	150	50	30	150	75	60
		> 50 ≤ 150	2500			100					
		> 150 ≤ 500	1200			100					
	Fossil	≤ 50	5000			150			125		
		> 50 ≤ 150	2500			100					
		> 150 ≤ 500	1200			100					
Automatic	Biogenic	≤ 50	3000	1000	500	100	30	20	150	60	40
		> 50 ≤ 150	2500			80					
		> 150 ≤ 500	1200			80					
	Fossil	≤ 50	3000			100			125		
		> 50 ≤ 150	2500			80					
		> 150 ≤ 500	1200			80					

NOTE 1: The dust values in this Table are based on the experience of the gravimetric filter method. The method used needs to be referred to in the test report. The particulate matter emission measured according to this European Standard does not include condensable organic compounds which may form additional particulate matter when the flue gas is mixed with ambient air. The values are therefore not directly comparable with values measured by dilution tunnel methods. Neither can they be directly translated into ambient air particulate concentrations.

NOTE 2: Additional test methods and emission limits which apply in some countries are given in the A-Deviations in Annex C.

[a] Referred to dry exit flue gas, 0 °C, 1013 mbar.

[b] Boilers of class 3 for type E-fuels according to 1.2.1 or e-fuels according to 1.2.3 in this Table and marked with the classification E-fuels and e-fuels do not need to fulfil the requirements for the dust emissions. The actual value shall be stated in the technical documentation and shall not exceed 200 mg-m3 at 10 % O2.

Measurement results: VG 80

Boiler output	Average values									
	Measured values						Converted values O_2=10%			
	O_2 [%]	CO_2 [%]	CO [ppm]	OGC/THC [ppm]	NO_x [ppm]	Dust [mg/m^3]	CO [mg/m^3]	OGC/THC [mg/m^3]	NO_x [mg/m^3]	Dust [mg/m^3]
Nominal (average values)	8.32	11.24	1087	7	92	55	1176	10	164	48

Test evaluation:
VG 80 (Wood - A) meets at nominal output the emission requirements for **Class 4**, as per ČSN EN 303-5:2013 Table 6.

Measurement results: VG 100

Boiler output	Average values									
	Measured values						Converted values O_2=10%			
	O_2 [%]	CO_2 [%]	CO [ppm]	OGC/THC [ppm]	NO_x [ppm]	Dust [mg/m^3]	CO [mg/m^3]	OGC/THC [mg/m^3]	NO_x [mg/m^3]	Dust [mg/m^3]
Nominal (average values)	6.81	12.60	1226	7	127	32	1188	8	201	25

Test evaluation:
VG 100 (Wood - A) meets at nominal output the emission requirements for **Class 4**, as per ČSN EN 303-5:2013 Table 6.

Accredited test number:	**1004.1*** **1005.1***	Test title:	**Test of heat output input and efficiency** **Combustion efficiency test - emissions**

Test method:	ČSN EN 303-5:2013 Annex C, Deviation from Austria, C.2.2, C.2.3
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

Requirement		**Requirement specification**	**Test evaluation**
Boiler efficiency for nominal heat output and minimum heat output		ČSN EN 303-5:2013 Annex C, Deviation from Austria, C.2.2	Wood - A
Boiler	**Minimum efficiency**		
Heating boilers for solid fuels	**75 %**		+
a) manually loaded			
up to 10 kW	79 %		
>10 to 200 kW	**(71.3 + 7.7 log Pn) %**		+
>200 kW	89 %		
a) automatically loaded			
up to 10 kW	80 %		
>10 to 200 kW	(72.3 + 7.7 log Pn) %		
>200 kW	90 %		
NOTE *Pn is the nominal heat output (Qn in this standard)*			

Requirement							**Requirement specification**	**Test evaluation**
Emission limits							ČSN EN 303-5:2013 Annex C, Deviation from Austria, C.2.3	Wood - A
Small burners used for solid fuels manually loaded								
Parameter	Emission limits mg-MJ							
	Wooden fuels		Other standardised biogenous fuels		Fossil fuels			
	Room heaters	Central heaters	< 50 kW nominal heat output	> 50 kW nominal heat output	< 50 kW nominal heat output	> 50 kW nominal heat output		
CO	1100	500	1100	500	1100	500		-
NO_x	150	150/100[a]	300	300	100	100		
OGC/THC	80/50[a]	50/30[a]	50	30	80	30		
Dust	60/35[a]	50/30[a]	60/35[a]	60/35[a]	50/35[a]	50/35[a]		
[a] Values applying as from 1.1. 2015.								

Measurement results: VG 80

Boiler output	Minimum efficiency	Measured efficiency
Nominal	86.0	88.8
Minimum		88.6

Test evaluation:

The measured efficiency of VG 80 (Wood - A) is **higher** than required.

Measurement results: VG 100

Boiler output	Minimum efficiency	Measured efficiency
Nominal	86.7	90.2
Minimum		90.1

Test evaluation:

The measured efficiency of VG 100 (Wood - A) is **higher** than required.

Measurement results: VG 80

Boiler output	Average values								
	Measured values					Converted values O_2=0%			
	O_2 [%]	CO [ppm]	NO_x [ppm]	OGC/THC [ppm]	Dust [mg/m3]	CO [mg/MJ]	NO_x [mg/MJ]	OGC/THC [mg/MJ]	Dust [mg/MJ]
Nominal (average values)	8.32	1087	92	7	55	600	84	5	24

Test evaluation:
The measured emission values for VG 80 (Wood – A) **exceed** the specified values.

Measurement results: VG 100

Boiler output	Average values								
	Measured values					Converted values O_2=0%			
	O_2 [%]	CO [ppm]	NO_x [ppm]	OGC/THC [ppm]	Dust [mg/m3]	CO [mg/MJ]	NO_x [mg/MJ]	OGC/THC [mg/MJ]	Dust [mg/MJ]
Nominal (average values)	6.81	1226	127	7	32	607	103	4	13

Test evaluation:
The measured emission values for VG 100 (Wood – A) **exceed** the specified values.

Accredited test number:	**1004.1*** **1005.1***	Test title:	**Test of heat output, input and efficiency** **Combustion efficiency test - emissions**

Test method:	ČSN EN 303-5:2013 Annex C, Deviation from Denmark, C.4.1, C.4.2
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

Requirement		**Requirement specification**	**Test evaluation**
Boiler Efficiency		ČSN EN 303-5:2013 Annex C, Deviation from Denmark , C.4.1	Wood - A
According to the Danish Construction Code BR08, Clause 8.5.1.4, Sub-clause 7, boilers for coal, coke, bio fuel or biomass shall have an efficiency equivalent to Class 3 in EN 303-5.			
Minimum efficiency	**(67 + 6 lVG Qn) %**		+
For boilers above 300 kW, the requirement corresponding to 300 kW shall be used.			

Requirement						**Requirement specification**	**Test evaluation**
Emission limits							
According to the Danish EPA Statutory Order no. 1432 of 11-12-2007, only Class 3 (or higher) is acceptable for Denmark.						ČSN EN 303-5:2013 Annex C, Deviation from Denmark , C.4.2	Wood – A
Stoking	**Fuel**	**Nominal heat output**	**Emission limit values** [a]				
			CO	**OGC/ THC**	**Dust**		
			mg/m³ at 10% O_2				
		kW	**Class**				
			3				
Manual	Biogenic	≤ 50	5000	150	150		+
		> 50 to 150	2500	100			
		> 150 to 300	1200				
	Fossil	≤ 50	5000	150	125		
		> 50 to 150	2500	100			
		> 150 to 300	1200				
Automatic	Biogenic	≤ 50	3000	80	150		
		> 50 to 150	2500				
		> 150 to 300	1200				
	Fossil	≤ 50	3000	100	125		
		> 50 to 150	2500	80			
		> 150 to 300	1200				
[a] Referring to dry exit flue gas, 0 °C, 1 013 mbar.							

Measurement results: VG 80

Boiler output	Minimum efficiency	Measured efficiency
Nominal	78.4	88.8
Minimum		88.6

Test evaluation:

Measured efficiency for VG 80 (Wood - A) is **higher** than required.

Measurement results: VG 100

Boiler output	Minimum efficiency	Measured efficiency
Nominal	79.0	90.2
Minimum		90.1

Test evaluation:

Measured efficiency for VG 100 (Wood - A) is **higher** than required.

Measurement results: VG 80

Boiler output	Average emission values						
	Measured values				Converted values O_2=10%		
	O_2 [%]	CO [ppm]	OGC/THC [ppm]	Dust [mg/m3]	CO [mg/m3]	OGC/THC [mg/m3]	Dust [mg/m3]
Nominal (average values)	8.32	1087	7	55	1176	10	48

Test evaluation:
The measured emission values VG 80 (Wood – A) **do not exceed** the specified values.

Measurement results: VG 100

Boiler output	Average emission values						
	Measured values				Converted values O_2=10%		
	O_2 [%]	CO [ppm]	OGC/THC [ppm]	Dust [mg/m3]	CO [mg/m3]	OGC/THC [mg/m3]	Dust [mg/m3]
Nominal (average values)	6.81	1226	7	32	1188	8	25

Test evaluation:
The measured emission values VG 100 (Wood – A) **do not exceed** the specified values.

Accredited test number:	**1004.1*** **1005.1***	Test title:	**Test of heat output, input and efficiency** **Combustion efficiency test - emissions**

Test method:	ČSN EN 303-5:2013 Annex C, Deviation from Germany, C.5.1, C.5.2
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

<table>
<tr><th colspan="6">Requirement</th><th>Requirement specification</th><th>Test evaluation</th></tr>
<tr><td colspan="6">Emission limits</td><td rowspan="8">ČSN EN 303-5:2013
Annex C,
Deviation from Germany, C.5.1</td><td rowspan="8">Wood - A</td></tr>
<tr><td colspan="6">Table 7 – Emission limits

The emission limits are regulated in Chapter 2, paragraphs 4, 5 and Annex 2 of the German Immission Control Ordinance "Erste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung über kleine und mittlere Feuerungsanlagen - 1. BImSchV)". Boilers operated with solid fuels shall only be installed, possess the quality and be put into operation if they fulfil the following specifications of the 1. BImSchV:</td></tr>
<tr><td></td><td>Fuel acc. to §3 (1)</td><td>Nominal output range kW</td><td>Dust g/m^3</td><td>CO g/m^3</td></tr>
<tr><td rowspan="4">Stage 2: Appliances, which will be installed after 31.12.2014</td><td>Numbers 1 to 5a</td><td>≥ 4</td><td>0.02</td><td>0.4</td></tr>
<tr><td rowspan="2">Numbers 6 to 7</td><td>≥ 30 ≤ 500</td><td>0.02</td><td>0.4</td></tr>
<tr><td>> 500</td><td>0.02</td><td>0.3</td></tr>
<tr><td>Numbers 8 to 13</td><td>≥ 4 < 100</td><td>0.02</td><td>0.4</td></tr>
<tr><td colspan="6">NOTE Differing from sentence 1 for firing systems (appliances) which will exclusively be fired by fuels according §3 article 1 Number 4 in the form of split logs, the limits according Stage 2 apply for firing systems (appliances) if they are installed after 31.12.2016.</td></tr>
</table>

Measurement results: VG 80

Boiler output	Average emission values				
	Measured values			Converted values O_2=13%	
	O_2 [%]	CO [ppm]	Dust [mg/m3]	CO [g/m^3]	Dust [g/m^3]
Nominal (average values)	8.32	1087	55	0.855	0.035

Test evaluation:
The measured emission values for VG 80 (Wood – A) **exceed** the specified values.

Measurement results: VG 100

Boiler output	Average emission values				
	Measured values			Converted values O_2=13%	
	O_2 [%]	CO [ppm]	Dust [mg/m3]	CO [g/m^3]	Dust [g/m^3]
Nominal (average values)	6.81	1226	32	0.864	0.018

Test evaluation:
The measured emission values for VG 100 (Wood – A) **exceed** the specified values.

Accredited test number:	**1004.1*** **1005.1***	Test title:	**Test of heat output, input and efficiency** **Combustion efficiency test - emissions**

Test method:	ČSN EN 303-5:2013 Annex C C.6 Deviation from Switzerland
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

<table>
<tr><th>Requirement</th><th>Requirement specification</th><th>Test evaluation</th></tr>
<tr><td colspan="2"></td><td rowspan="2">Wood - A</td></tr>
<tr><td colspan="2">Clause 4.4.7, Table 7
The emission limits are regulated in Annex 4 of the Swiss Ordinance on Air Pollution Control ([OAPC] SR 814.318.142.1) of 1985-12-16 (as at 2010-07-15).
Boilers operated with woody biomass shall only be put on the market if they fulfil the following specifications of the OAPC:
– declarations of conformity (Figure 20 OAPC);
– Figures 1, 212, 23 Annex 4 OAPC;
– Figures 31, 32 Annex 5 OAPC.
Emissions for boilers operated with coal or wood fuels shall not exceed the following limits:</td></tr>
<tr><td rowspan="2">Type of installation</td><td colspan="2">Particular requirements (emission limits)[a] for carbon monoxide (CO) and particulate matter (dust)</td><td rowspan="5">ČSN EN 303-5:2013
Annex C
C.6 Deviation from Switzerland</td></tr>
<tr><td>CO (mg-m^3)</td><td>Dust (mg-m^3)</td></tr>
<tr><td>Boilers for log Wood - and boilers for coal, manual stoking</td><td>800</td><td>50</td><td>-</td></tr>
<tr><td>Boilers for chipped Wood - and boilers for coal, automatic stoking</td><td>400</td><td>60</td><td rowspan="2"></td></tr>
<tr><td>Boilers for Wood Pellets, automatic stoking</td><td>300</td><td>40</td></tr>
<tr><td colspan="4">[a] Referred to oxygen basis:
– for boilers for natural state wood 13 % volume;
– for boilers for coal 7 % volume.</td></tr>
<tr><td colspan="3">The sulphur content of coal, coal briquettes and coke shall not exceed 3 %. Boilers operated with non-woody biomass shall comply with the following specifications of the OAPC:
– Figures 741, 742, 743 Annex 2 OAPC;
– Figures 81, 82 Annex 3 OAPC.
According to Figure 743, Annex 2 OPAC, non-woody biomass, such as biogenic waste and products from agriculture, may only be burnt in boilers with a heat input of at least 70 kW. Such units need an approval and shall meet stronger emission limits according to Figure 742, Annex 2 OAPC.</td><td>0</td></tr>
</table>

Measurement results: VG 80

Boiler output	Average emission values				
	Measured values			Converted values O_2=13%	
	O_2 [%]	CO [ppm]	Dust [mg/m3]	CO [mg/m3]	Dust [mg/m3]
Nominal (average values)	8.32	1087	55	855	35

Test evaluation: The measured emission values for VG 80 (Wood – A) **exceed** the specified values.

Measurement results: VG 100

Boiler output	Average emission values				
	Measured values			Converted values O_2=13%	
	O_2 [%]	CO [ppm]	Dust [mg/m3]	CO [mg/m3]	Dust [mg/m3]
Nominal (average values)	6.81	1226	32	864	18

Test evaluation: The measured emission values for VG 100 (Wood – A) **exceed** the specified values.

Accredited test number:	**1004.1*** **1005.1***	Test title:	**Test of heat output, input and efficiency** **Combustion efficiency test - emissions**

Test method:	ČSN EN 303-5:2013 Annex C, C.8 Deviations from Italy
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Requirement	**Specification of requirement**		**Test evaluation**
Italian emission limits for heating plants fuelled with biomass solid fuels	Emissions refer to an 11% O_2		
Plant nominal thermal output (MW)	**>0,035 ÷ <0,15** (>35kW÷<150kW)	**>0,15 ÷ <1** (>150kW÷<1000kW)	
Total Particulate Matter	200mg/Nm^3	100mg/Nm^3	+
Total Organic Carbon (COT) Carbon Monoxide (CO)		- 350 mg/Nm^3	
Nitrogen Dioxide (expressed as NO_2)		500 mg/Nm^3	
Sulphur Dioxide (expressed as SO_2)		200mg/Nm^3	
Italian emission limits for heating plants fuelled with non-biomass solid fuels			
	Emissions refer to an 6% O_2		
Nominal Thermal output (MW)	>0.35 (350kW)		
Total Particulate Matter	50 mg/Nm3		0

Measurement results: VG 80

Boiler output	Average emission values				
	Measured values			Converted values O_2=11%	
	O_2 [%]	CO [ppm]	Dust [mg/m^3]	CO [mg/m^3]	Dust [mg/m^3]
Nominal	8.32	1087	55	286	12

Test evaluation: The measured emission values for VG 80 (Wood – A) **do not exceed** the specified values.

Measurement results: VG 100

Boiler output	Average emission values				
	Measured values			Converted values O_2=11%	
	O_2 [%]	CO [ppm]	Dust [mg/m^3]	CO [mg/m^3]	Dust [mg/m^3]
Nominal	6.81	1226	32	289	6

Test evaluation: The measured emission values for VG 100 (Wood – A) **do not exceed** the specified values.

Accredited test number:	**1006.1***	Test title:
	1005.1*	**Function test of control, regulation and safety elements**
	1006.2*	**Combustion efficiency test – emissions**
		Test of device for dissipating excess heat

Test method:	ČSN EN 303-5:2013 Art. 5.13, 5.15, 5.16.3 ČSN EN 303-5:2013 Art. 5.9, 5.10.4
Sample tested:	VG 80, VG 100
Measuring equipment used:	Chapter III - Measuring and test equipment

Test results:

Requirement	Requirement specification	Test evaluation	Note
Function check of the temperature controller and safety temperature limiter at the boiler The water-side flow rate shall comply with that specified for the nominal heat output test. The flow temperature of 75 °C shall not be exceeded at the start of the test °C. Adjust the firing so that it corresponds to the nominal heat output Q_N of the boiler. A steady state condition shall be reached and the outlet pressure at the flue gas section shall be according to the nominal heat output setting. For manual stoked boilers, the boiler shall be refuelled after reaching steady state with a full batch before starting the test. The dissipated output shall be reduced to (40 ± 5) % of the nominal heat output of the boiler, circulating pump running in continuous operation; temperature controller adjusted to maximum set value. When the temperature controller is operating normally, the measured flow temperature shall not exceed 100 °C; the safety temperature cut out or limiter or the device for dissipating excess heat shall not trigger. Repeat the test with the temperature controller out of function. This time, check if the safety temperature limiter-detector switches off the firing system at the highest value specified by the boiler manufacturers and if all hazardous operation states are avoided (see 4.1).	ČSN EN 303-5:2013 Art. 5.13	+	

Requirement	Requirement specification	Test evaluation	Note
Function test on the device for dissipating excess heat (partly or non-disconnectable firing system) Adjust the firing so that it corresponds to the nominal heat output QN of the boiler, a steady state condition is reached and the outlet pressure at the flue gas section is according to the nominal heat output. Put the temperature controller out of function. Maintain the function of the safety temperature limiter. The heat consumption is set to 0; water circulation in the boiler is permitted. Check if the safety temperature limiter switches off the firing system and the device for dissipating excess heat works properly and all hazardous operation states are avoided. **The cold water shall be kept at a temperature of (10 ± 5) °C and a pressure of maximum 2 bar. (Deviations are permissible if they are specified in the installation instructions.)** For the evaluation of the temperatures and the CO-concentrations, only mean values at a maximum average time of one minute shall be considered.	ČSN EN 303-5:2013 Art. 5.15	+	
Loss of combustion air supply The safety of the heating boiler shall be checked at maximum heat input under the following conditions: – failure of combustion air fan; – failure to close of the adjustable combustion air supply. In each case, only one failure shall be simulated. The CO concentrations in the boiler shall not exceed 5 % volume. The measurement of CO concentration shall be carried out in the flue gas measuring section. ***Test of combustion air supply loss***	ČSN EN 303-5:2013 Art. 5.16.3	+	
The heat carrier (water) does not become heated to a dangerous extent (≤ 110 °C);	ČSN EN 303-5:2013 Art. 4.1	+	

Note:
+ Compliant
- Non-compliant
0 Not applicable
x Not assessed

Measurement results: VG 20

Temperature controller		
Temperature	**[°C]**	**Note:**
Pre-set	85 °C	Temperature set on the operating thermostat regulator
Shutdown	82 °C	Fan switched off (suppression mode)
Restoration of operation	75 °C	Fan restored

Temperature limiter (manual restoration of temperature) STB		
Temperature	**[°C]**	**Note:**
Pre-set	95 °C	Temperature set on the temperature limiter
Shutdown	93 °C	Fan switched off
Restoration of operation	The boiler irreversibly switched off. In order to restore operation, a manual intervention required, after the temperature drops under the limiter switching temperature	

Test evaluation: Proper functioning of safety elements has been verified.

Test results: VG 80

Meassurement and calculated values:	Unit	Value	Limit	Note
Outlet water temperature - max	°C	103	110	
Water cooling temperature – inlet from safety valve - average	°C	5		
Water cooling temperature – outlet from safety valve - average	°C	24		
Water flow - max	kg/h	900		
Outlet water temperature during open the valve for cooling water	°C	95		
Pressure of cooling water	bar	2		

Test evaluation: During the safety temperature regulator test, the water temperature at the output from the boiler did not exceed 110°C.

Measurement results: VG 100

Temperature controller		
Temperature	**[°C]**	**Note:**
Pre-set	85 °C	Temperature set on the operating thermostat regulator
Shutdown	82 °C	Fan switched off (suppression mode)
Restoration of operation	75 °C	Fan restored

Temperature limiter (manual restoration of temperature) STB		
Temperature	**[°C]**	**Note:**
Pre-set	95 °C	Temperature set on the temperature limiter
Shutdown	93 °C	Fan switched off
Restoration of operation	The boiler irreversibly switched off. In order to restore operation, a manual intervention required, after the temperature drops under the limiter switching temperature	

Test evaluation: Proper functioning of safety elements has been verified.

Test results: VG 100
double safety valve

Meassurement and calculated values:	**Unit**	**Value**	**Limit**	**Note**
Outlet water temperature - max	°C	105	110	
Water cooling temperature – inlet from safety valve - average	°C	16		
Water cooling temperature – outlet from safety valve - average	°C	25.5		
Water flow - max	kg/h	1100		x2
Outlet water temperature during open the valve for cooling water	°C	96		
Pressure of cooling water	bar	2		

Test evaluation: During the safety temperature regulator test, the water temperature at the output from the boiler did not exceed 110°C.

Tested by: Ing. Michal Havlů Date: 12/2015 Signed:

Reviewed by: Ing. Stanislav Buchta Date: 12/2015 Signed:

The test methods in this Report were applied without deviations, additions or exceptions.

V. List of referenced source materials

The tests were performed based on

- Order X-54326 dated 2015-10-23 (received on 2015-10-26)
- Contract X-54326/32
- ČSN EN 303-5:2013 – Heating boilers - Part 5: Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW - Terminology, requirements, testing and marking
- SZU Methodology 0211 M 001 – Measurement of solid pollutants by manual methods
- SZU Methodology 0211 M 002 – Measurement of gaseous emissions
- Technical documentation to Task 32-0240
- Instructions for assembly, installation and operation of the boiler
- A set of required drawing documentation as per ČSN EN 303-5:2013; VG 80, VG 100

The persons named below are accountable for the accuracy of the above-specified data:

Ing. Stanislav Buchta
Head of Boilers and Industrial Heat Equipment Department

Mr. Milan Holomek
Head of Heat and Environment-Friendly Equipment Test Station