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Testing of wood boiler ASTRA H-32E

(5 appendices)

This report is a revised version from the report dated 2014-11-19. The revision concerns an additional data plate in appendix 1 and a change of the boiler type name.

The assignment

Testing the emissions and efficiency at nominal heat output for the wood boiler Astra H-32E in accordance with European Standard EN 303-5:2012.

This report does not include testing and assessment of the following clauses:
Construction requirements, design requirements, safety tests, temperature control and limiting devices and heating boiler accessories.

Item for testing

Wood boiler type Astra H-32E. The boiler is manufactured by Astra Machinery Plant, Alytus, Lithuania. The boiler arrived at SP on 9th October 2014. The boiler was in used condition.

Informative material supplied

An instruction manual with the title "Installation och användarmanual Vedpannor Astra H-25 E, Astra H32E, Astra H45-E" was delivered at the point of testing.

Drawings: Korpusas H-32E.01.000SB

Test arrangement

The wood boiler was connected to a test rig consisting of a circulation pump, flow meter, valves and heat exchanger, which enabled the circulation flow and the supply and return temperatures to be maintained at the desired values.

The chimney diameter was 150 mm, with a height of about 6 m above floor level.

Test procedure

This test report relates only to the actual item tested.

Testing was carried out at/by SP's Energy Technology Department during October 2014, in accordance with European Standard EN 303-5:2012, chapter 5 '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'.

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The emission values were measured continuously during the test period.

The mass of basic firebed was indicated by a scale. Additionally, CO₂ concentration was also taken into account when judging the basic firebed.

The fuel used for the test was birch wood. For fuel specifications see appendix 3.

The following parameters were measured and/or calculated (as appropriate) every 20 seconds (mean value from measurement every 10 seconds):

- Flow and return temperatures
- Circulation flow rate through the boiler
- Ambient temperature
- Flue gas temperature
- Draught
- Electrical power consumption
- CO₂ concentration
- CO concentration
- O₂ concentration
- THC concentration (Total Hydro Carbon)
- NO_x concentration
- Heat output

Particulate concentration was measured intermittently at nominal heat output.

The flow and return temperatures were measured directly at the boiler connections. The flue gas temperature was measured at a distance of about two chimney diameters from the connection of the flue gas duct.

Results

The table below shows a summary of the test results. For complete results see appendix 2.

Table 1, Testing results

	Unit	Nominal heat output
Efficiency	%	87
Heat output (mean value)	kW	36
Dust concentration	mg/m ³ _n dry gas at 10 % O ₂	44
CO	mg/m ³ _n dry gas at 10 % O ₂	2477
OGC	mg/m ³ _n dry gas at 10 % O ₂	62
NO _x (as NO ₂)	mg/m ³ _n dry gas at 10 % O ₂	124

Comments

The wood boiler – Astra H-32E - complies with the Class 3 emission requirements for CO, OGC and dust in accordance with EN 303-5:2012. The boiler also complies with the Class 4 requirements for efficiency, but the boiler cannot be classified in Class 4 because it did not meet the class requirements for class 4, as all efficiency and emission limits of that class shall be fulfilled, see clause 4.4.1 in EN 303-5:2012.

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Appendices

Appendix 1 Identification

Appendix 2 Results

Appendix 3 Test fuel specification

Appendix 4 Instrumentation and uncertainty of measurement

Appendix 5 Drawing

Appendix 1

Identification



Figure 1, Identification

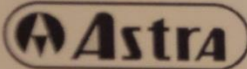

Heating boiler Astra H-32E			
Nominal heat output: 32 kW firewood / 33 kW briquettes			
Boiler class according to EN 303-5 standard: Class 3 EN 303-5		Maximal allowable operating pressure, bar: Pmax=2 bar	
Maximal allowable operating temperature, C°: Tmax=95°C		Water content, litres: V=78 litres	
Electrical connection parameters (V, Hz, W, A); 230 V / 50 Hz/57Wmax  2A			
Weight, kg: 310 kg	Fuel class: A, C2	Serial number: 8377	Year of production: 2012
Manufacturer: 		Ulonų 33 str., LT-62161 Alytus, Lithuania Tel. +370 315 75449 www.astra-gas.lt info@astra.lt	
			

Figure 2, Data plate

Appendix 2

Results

The clauses below refer to the corresponding clauses in EN 303-5:2012.

4. Requirements

Table 2, Requirements

Clause	Results (Pass or Fail)	Remark
4.4 Performance requirements		
4.4.2 Boiler efficiency	Pass	Class 4
4.4.4 Draught	Pass	
4.4.5 Combustion period	Pass	
4.4.6 Minimum heat output	-	The boiler shall be connected to an accumulator tank.
4.4.7 Emission limits	Pass	Class 3

Note: The other clauses in chapter 4 have not been evaluated in this report.

Appendix 2

5.7 Boiler performance test
5.8.2, 5.8.4 and 5.9.1 at nominal heat output

The boiler has a rated output at 32 kW

Table 3, Test results

	Unit	Results
Test date		15/10/2014
Test duration	h	4,66
Atmospheric pressure	mbar	990
Ambient temperature	°C	20,5
Quantity of fuel supplied	kg	44
Lower calorific value (as fired basis)	MJ/kg	15,6
Flow temperature	°C	86,4
Return temperature	°C	64,6
Circulation flow, (mean value)	m ³ /h	1,4
Heat output (mean value)	kW	35,8
Efficiency	%	87
Flue draught (chimney)	Pa	-21
Flue gas temperature, (mean value)	°C	194
CO ₂ - concentration, (mean value)	%	12,2
O ₂ - concentration, (mean value)	%	7,9
CO - concentration, (mean value)	ppm	2360
CO - concentration, (mean value)	mg/m ³ _n dry gas at 10 % O ₂	2477
THC concentration, (mean value) (expressed as propane equivalent)	ppm	40
OGC - concentration, (mean value)	mg/m ³ _n dry gas at 10 % O ₂	62
Dust concentration	mg/m ³ _n dry gas at 10 % O ₂	44*
NO _x concentration (mean value)	ppm	72
NO _x (as NO ₂)	mg/m ³ _n dry gas at 10 % O ₂	124

* Dust concentration is a mean value from the four samples in the table below

Table 4, Dust concentration from the four different samples

	Unit	Sample 1	Sample 2	Sample 3	Sample 4
Dust concentration	mg/m ³ _n dry gas at 10 % O ₂	58,1	43,4	34,7	38,5

Appendix 2

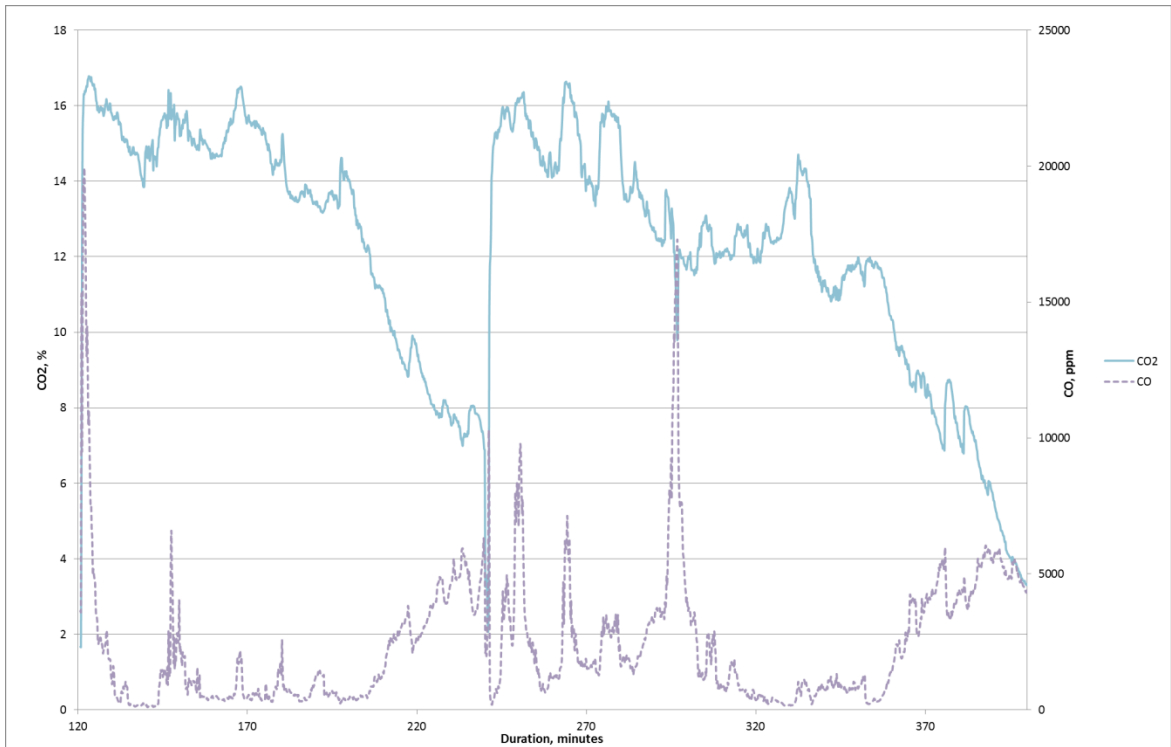


Figure 3, CO and CO₂ emissions at nominal heat output

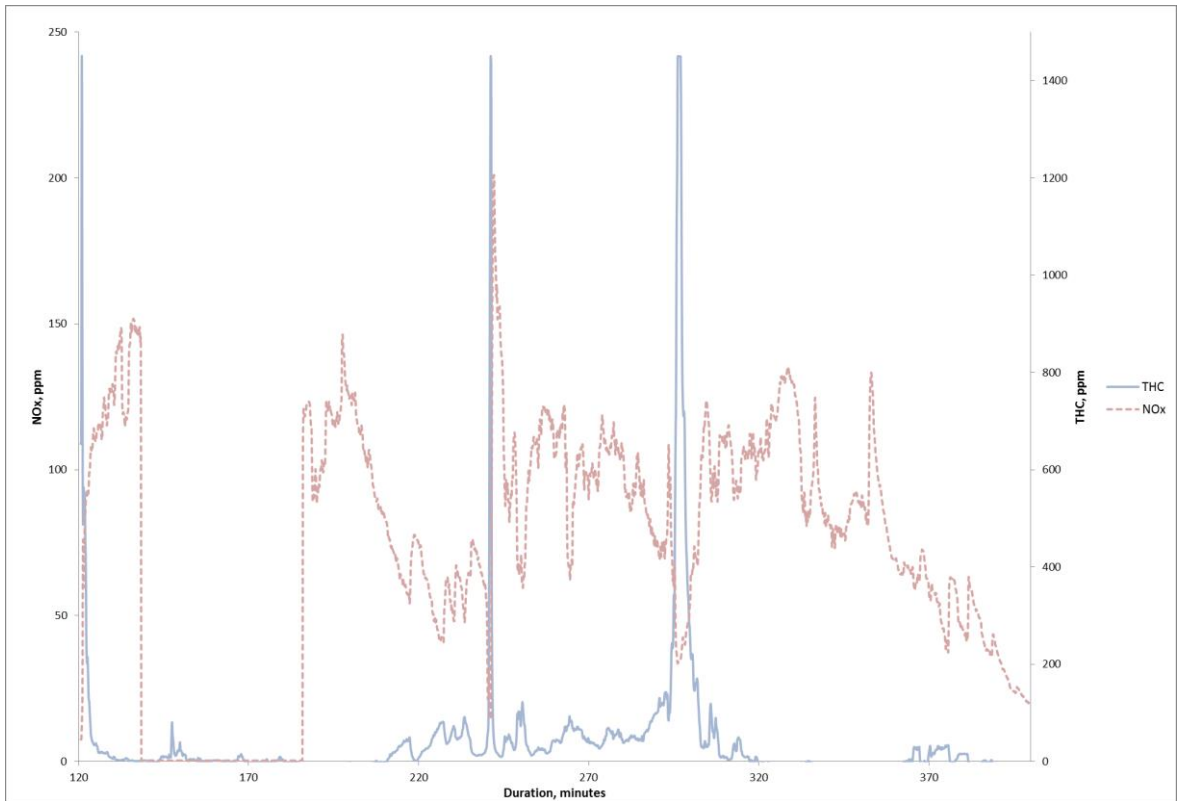


Figure 4, THC and NO_x emissions at nominal heat output

Appendix 2

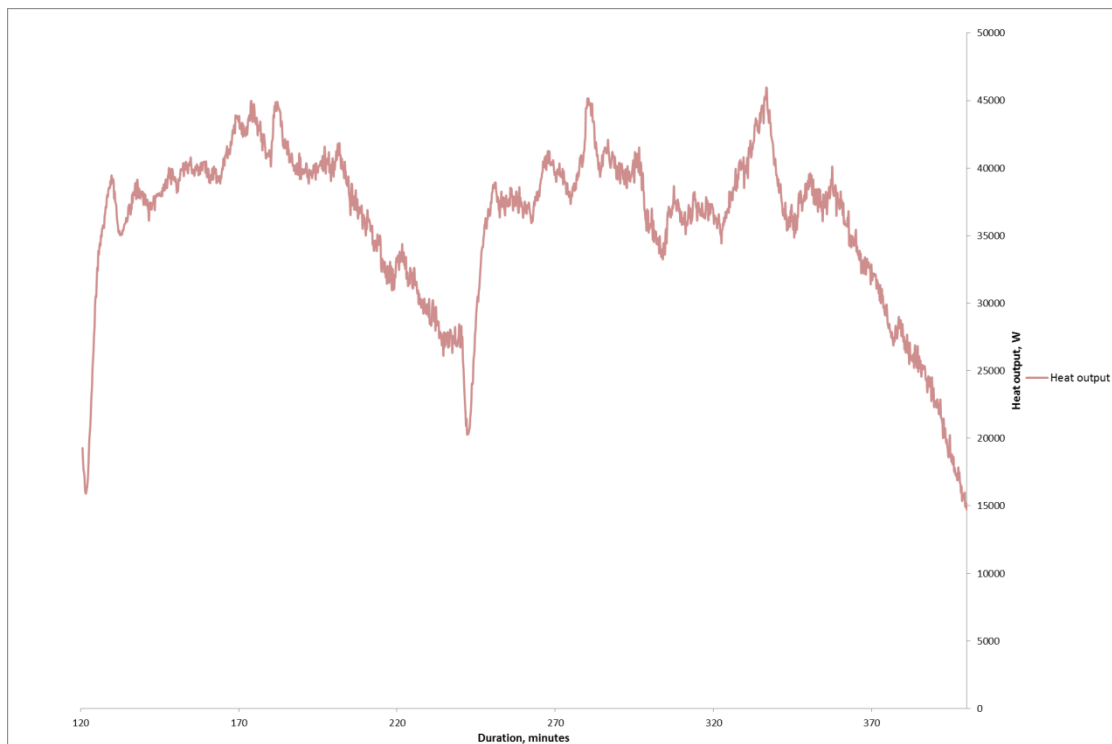


Figure 5, Nominal heat output

Appendix 3

Test fuel specifications

Test methods

Water content:	CEN/TS 14774-2
Ash content:	mod. SS 18 71 71)
Sulphur content:	CEN/TS 15289
Carbon, hydrogen and nitrogen content:	CEN/TS 15104
Oxygen content:	Calculated as a difference
Calorific value:	CEN/TS 14918

Results

Test fuel as fired basis

Water content, % of mass	14,5
Sulphur content, S, % of mass	<0,02
Carbon content, C, % of mass	42,7
Hydrogen content, H, % of mass	5,3
Nitrogen content, N, % of mass	0,1
Net calorific value at constant pressure, MJ/kg	15,6

Test fuel as dry basis

Ash content, % of mass	0,4
Sulphur, S, % of mass	<0,02
Carbon content, C, % of mass	49,9
Hydrogen content, H, % of mass	6,2
Nitrogen content, N, % of mass	0,13
Oxygen content, O, (diff) % of mass	43,4
Net calorific value at constant pressure, MJ/kg	18,7

Appendix 4

Instrumentation and uncertainty of measurement

The designations listed below refer to SP Energy Technology's quality system

Resistance thermometer, PT-100	ETf-PT01-VV1
Resistance thermometer, PT-100	ETf-PT04-VV1
Thermocouple, type K	ETf-QD Db 3
Water flow meter	Inv.nr. 202 744
Data logging system	Inv.nr. 201 673
Dust sampling equipment	Inv.nr. 200 399
Differential pressure gauge Furness FCO 12	Inv.nr. 202 747
CO/CO ₂ - analyzer XStream (CO 0-20000 ppm)	Inv.nr. 901 077
THC-analyzer JUM FID, modell 3-900	Inv.nr. 902 300
O ₂ -analyzer M.&C, Modell PMA 10	Inv.nr. 202 589
NO _x -analyzer EcoPhysics CLD 70 EI	Inv.nr. 201 369
Balance Sartorius LC34	Inv. nr 201 639

Uncertainty of measurement

Temperature difference, radiator circuit	±0,05 °C
Boiler temperature	±0,5 °C
Flue gas temperature	±3 °C
Ambient temperature	±1 °C
Surface temperature	±2 °C
Negative pressure in chimney	±10 %
Liquid flow, radiator circuit	±1 %
Fuel quantity	±0,01 kg
CO ₂ -concentration	±0,3 %-points
CO-concentration	±296 ppm
O ₂ -concentration	±0,4 %-points
THC-concentration	±4 ppm

Appendix 4

NO _x -concentration	±15 ppm
OGC (mg/m ³ _n)	±15 % of measured value
CO (mg/m ³ _n)	±15 % of measured value
NO _x (mg/m ³ _n)	±15 % of measured value
Heat output	±1,5 % of measured value
Boiler efficiency	±2,0 %-points
Dust concentration	±10 % of measured value
Table values	
cp	±0,1 %
ρ	±0,1 %
Analysed values	
Heating value	±0,12 MJ/kg

The uncertainty has been calculated according to EA-4/16 with a coverage factor k=2

Appendix 5

Drawing

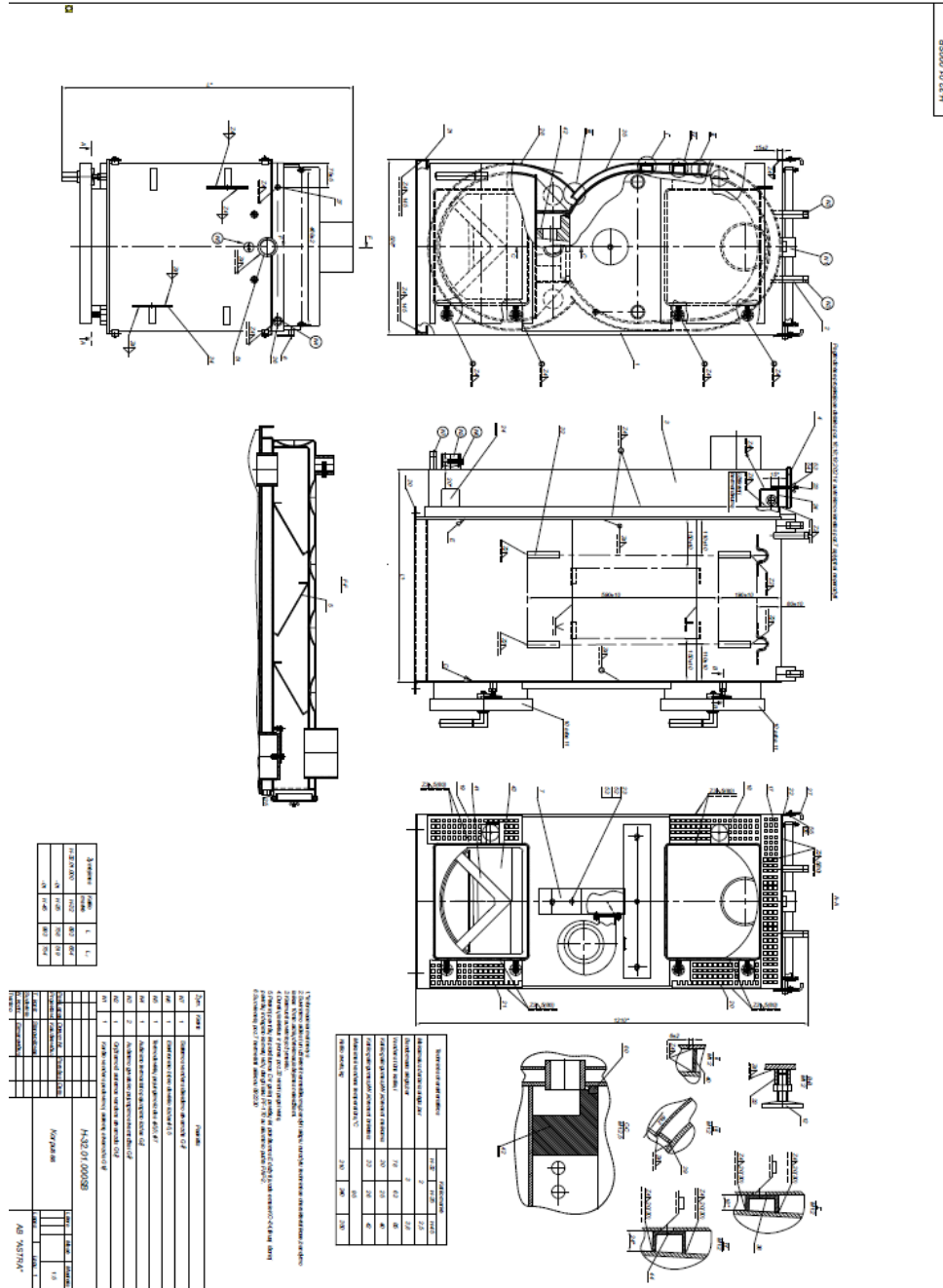


Figure 6, General drawing