

**Testing methods and
emission requirements
for small boilers
(< 300 kW) in Europe**

Motiva's Publication B 3 / 2000

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Publication series layout: Meridian X and Jenni Turunen, Motiva

Preface

This report is a summary of the Testing methods and emission requirements for small boilers in Europe (VTT Energy report ENE33/T0060/99). The study is carried out VTT Energy and commissioned by Motiva, Information Centre for Energy Efficiency and Renewable Energy Sources. The translation of the Finnish report into English is financed by the ALTENER Bioenergy Network – AFB-net and the report is distributed through the AFB-net.

Testing methods and emission requirements for small boilers in European countries are briefly reviewed in the report. The countries included are Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, the Netherlands, Portugal, Spain, Sweden, Switzerland and United Kingdom. The new standard for small boilers fired with solid fuels to be applied within the European Union is also described.

Jyväskylä, January 2000

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1 Contents

Testing methods and emission requirements for small boilers (< 300 kW) applied in those European countries that are the most potential target countries for the exports of the Finnish manufacturers of small boilers are briefly reviewed in the report. Efficiency and emission requirements are surveyed and testing methods applied in each country are presented briefly. The countries included are Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, the Netherlands, Portugal, Spain, Sweden, Switzerland and United Kingdom. The new standard for small boilers fired with solid fuels, applied within the European Union, is also described.

2 Testing methods and emission limits in different countries

2.1 Finland

In Finland a testing standard SFS 4800 for small boilers fired with solid fuels was developed in the early 1980's. The standard defines testing equipment, coupling of the boiler to the equipment, testing procedure and fuel alternatives, and reporting of results. The standard can be used as applicable if it deviates from the operation manual of the boiler tested.

So-called combustion efficiency and boiler efficiency are measured in heating tests. According to this standard the combustion efficiency is the quantity of 100 % - energy lost with flue gas. The loss comprises the heat of flue gas and the energy of combustible gas in the flue gas. The boiler efficiency gives the percentage of fuel energy transferred to a heat accumulator, and also includes losses through insulation and ash from the boiler. In practice the efficiency is also reduced by losses through the insulation of the heat accumulator and pipelines. Part of these can be recovered if the equipment is located within a heated building.

The testing procedure includes a test of accumulating heating and, if required by the client, a test of applicability to so-called direct heating by performing a test simulating this heating method at least at the following capacities:

- test with continuous operation at 1/1 capacity
- test with continuous operation at 1/2 capacity
- test with continuous operation at 1/5 capacity
- no-load test

CO₂ and CO contents, and temperature of flue gas are measured for flue gases. These quantities are used for calculating efficiency. Fuel consumption is determined by weighing, and the efficiency is calculated with a direct method.

There are no general directions for small boilers in Finland. Wood-firing in small boilers can be banned only on the basis of neighbours' complaints to local authorities. The aim of the standard developed in the early 1980's was primarily to test the gross effect and efficiency of boilers.

Finland will introduce the new EN 303-5 standard as the testing method. There is no information available about plans for defining general emission limits.

2.2 Austria

The wood-fired boilers are tested according to the European Standard EN 303-5 (*Heating boilers for solid fuels, hand and automatically stoked, nominal heat output of up to 300 kW*). This standard was prepared under the lead of Austrian experts and hence it was quickly taken into use in Austria.

Although the wood-fired boilers are tested according to EN 303-5 in Austria, regulations deviating from the standard have been given for efficiency and emissions. These country-specific deviations are in force until the standard definitions are included in any EU directive.

The regulations in force for wood-fired devices at nominal output in Austria are presented in Table 1 (law art. 15a B-VG).

Table 1. Emission limits for wood-fired small boilers applied in Austria.

Device type	Emission limit (mg/MJ)			
	CO	NO _x	OGC	Particles
Manually fed	1 100	150	80	60
Automatically fed	500	150	40	60
	750 (30 % part. output)			

In Austria the emissions are given in mg/MJ, which means mg for energy unit fed into the boiler. This cannot be directly converted into mg/nm³ without access to data on process conditions. The CO emission of 1 100 mg/MJ is equal to around 1 700 nm³, or 1 400 ppm calculated for 13 % O₂ content. The NO_x content is, respectively about 230 mg/nm³, or 110 ppm, and the hydrocarbon content (OGC) 120 mg/nm³.

The efficiency requirement also deviates from that given in EN 303-5 standard. The efficiency requirement applied in Austria is presented in Table 2.

Table 2. Efficiency requirement applied for wood-fired small boilers in Austria.

Device type	Efficiency	Efficiency requirement, %
Manually fed	< 10	73
	10 - 200	65.3 + 7.7 log Q _n (= 73 - 83 %)
	> 200	83
Automatically fed	< 10	76
	10 - 200	68.3 + 7.7 log Q _n (= 76 - 86 %)
	> 200	86

2.3 Belgium

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.4 Denmark

There is a governmental system of investment subvention, through which it is possible to obtain support for investments in biomass-fired boilers. The amount of subvention is dependent on the output and emissions of the boiler and can be granted only for type-approved boilers. The percentage of investment grant ranges from 10 to 26 %. Small boilers are tested according to EN 303-5 standard, but the efficiency and emission limits for type approval differ from those given in the EN standard. The minimum emission limits are given in Table 3.

Table 3. Type approval requirements in Denmark.

Fuel	Feed method	CO content at part output	CO content at nominal output	Particle content at nominal output
		ppm (10 % O ₂)	ppm (10 % O ₂)	ppm (10 % O ₂)
Billets, pellets, saw-dust, chips, corn	Manual	5 000	5 000	300
Billets, pellets, saw-dust, chips, corn	Automatic	1 500	1 000	300
Straw	Manual	8 000	8 000	600
Straw	Automatic	4 000	3 000	600

The output of automatic devices shall not exceed 250 kW and that of manually fed ones 400 kW in Denmark.

The minimum efficiencies of various devices shall be as follows:

$$\begin{array}{lll} \text{manually fed} & 59 + 6 \log Q_n & (= 59 - 74.6 \%) \\ \text{automatic} & 70 + 6 \log Q_n & (= 70 - 84.4 \%) \end{array}$$

except for straw:

$$\begin{array}{lll} \text{manually fed} & 50,1 + 6 \log Q_n & (= 50.1 - 65.7 \%) \\ \text{automatic} & 58 + 6 \log Q_n & (= 58 - 72.4 \%) \end{array}$$

The emission limits given above are related to the type-approval and investment subvention system for boilers. The system is voluntary. The essential emission limits given by authorities, < 300 mg/nm³ (10 % O₂), concern only boilers of > 120 kW.

2.5 Estonia

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.6 France

There are no general requirements for < 2 MW biomass boilers. Small boilers are tested according to DIN 4702.

2.7 Germany

Standard DIN 4702 is used for testing wood-fired boilers. It is in principle similar to the new EN standard. The emission limits valid in Germany are presented in Table 4.

Table 4. Emission limits for the combustion of clean wood in Germany.

Output (kW)	Basis	Emission calculated for oxygen content	Emission limit			
			CO	Particles	OGC	NO _x
		%	mg/m ³	mg/ m ³	mg/ m ³	mg/ m ³
15 - 50	1.BImSc hV	13	4 000	150	-	-
50 - 150	1.BImSc hV	13	2 000	150	-	-
150 - 500	1.BImSc hV	13	1 000	150	-	-
500 - 1 000	1.BImSc hV	13	500	150	-	-
1 000 - 5 000	TA Luft	11	250	150	50	500
5 000 - 50 000	TA Luft	11	250	50	50	500

The emissions are calculated for an O₂ content of 13 or 11 %, hence deviating from EN 303-5 standard, in which the O₂ percentage is 10 %.

2.8 Ireland

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.9 Italy

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.10 Latvia

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.11 Lithuania

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.12 The Netherlands

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.13 Portugal

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.14 Spain

There is neither a testing standard nor emission limits for small wood-fired boilers.

2.15 Sweden

A method developed by SP - Swedish National Testing and Research Institute is used for testing wood-fired boilers in Sweden (SP method 1419 - Wood-fired boilers: Environment and efficiency testing).

The testing method corresponds to the operation of the boiler coupled to a heat accumulator. A wood amount equal to about 400 MJ is burned during the test. The moisture content of the fuel shall be $18\% \pm 3\%$. Birch billets are used as fuel. The boiler is preheated using a fuel batch of 3 - 4 kg. The essential fuel batch is added on the ember formed. Sampling of flue gases is started after 5 minutes from feeding the test wood batch. Another fuel batch is fed as soon as the CO₂ content of flue gas has been reduced to 4 %. The measurement is finished as soon as the second fuel batch has burned so far that the CO₂ content of flue gas has again been reduced to 4 %.

The quality of burning is measured on the basis of the content of organically bound carbon (OGC). The emission limit is 150 mg OGC/nm³ for O₂ content. Previously a so-called tar content was measured, the emission limit being 30 mg/MJ for wood-fired boilers. According to comparisons the present emission limit is slightly more stringent than the previous tar limit.

2.16 Switzerland

A voluntary type-approval testing has been used since 1994 in Switzerland. Since 1997 a VHe marking has been available for type-approved boilers from the Swiss Association on Wood Energy (VHe = Schweizerische Vereinigung für Holzenergie).

The Swiss emission limits are defined by an ordinance (*Swiss Ordinance on Air Pollution Control of 1985-12-16*). The limits are given in Table 5.

Table 5. Emission limits defined for wood-fired boilers in Switzerland.

Boiler output	20 kW - 70 kW	> 70 kW - 200 kW	> 200 kW - 500 kW	> 500 kW - 1 MW	> 1 MW - 5 MW	> 5 MW
Emission for oxygen content (%)	13	13	13	13	11	11
Particles (mg/m ³)	-	150	150	150	150	50
CO (mg/m ³)	4 000	2 000	1 000	500	250	250
CO (%)	0.32	0.16	0.08	0.04	0.02	0.02
OGC (mg C/m ³)	-	-	-	-	50	50

In principle this means that only the highest class of the boilers tested according to EN 303-5 is acceptable in Switzerland.

2.17 UK

There is neither a testing standard nor emission limits for small wood-fired boilers. Air Protection Law sets limits for particle emissions especially in densely-populated smoke control areas. Great Britain has given a deviation requirement for the new EN 303-5 standard due to more stringent particle size limits applied in Great Britain.

3 EN 303-5 standard

CEN¹⁾ approved the new European standard EN 303-5 (Heating boilers for solid fuels, hand and automatically stoked, nominal heat output of up to 300 kW) as an EN standard on 12 November 1998.

Standard EN 303-5 also covers other solid fuels in addition to wood. The solid fuels covered by the standard are given in Table 6.

Table 6. Solid fuels covered by the EN 303-5 standard.

Solid biofuels	Moisture content, %
billets	< 25
chips B1	15 - 35
chips B2	> 35
wood pellets and briquettes (only natural binding materials are accepted)	
sawdust	20 - 50
Fossil fuels	
bituminous coal	
lignite	
coke	
anthracite	

The flue gas emissions and efficiency are determined at nominal output and minimum output. At least a 50 % minimum output shall be achieved for manually fed boilers, and at least a 30 % output for automatically fed boilers. If a manually fed boiler is not able to achieve the 50 % part output it shall be equipped with a heat accumulator and the manufacturer shall give information about it.

The combustion cycle of manually fed boilers with one fill shall be at least two hours when burning biomass and at least four hours when burning fossil fuels. The operation time of automatically fed boilers shall be at least six hours.

The output of the boiler is measured on the basis of water flow and temperature difference. The fuel consumed during the test is weighed. The total efficiency of the system is calculated on the basis of these with a so-called direct method when the energy fed into the system and that obtained for cooling are known.

The EN 303-5 standard classifies the boilers into three classes on the basis of capacity. CO content, content or organically bound carbon (OGC) and particle content in flue gas emissions are measured. Emission limits for various boiler classes are presented in Table 7.

An analyser based on flame ionisation detector (FID) is used for measuring organically bound carbon. This device hence measures all carbon that exists in organic form in flue gases. The FID analyser is a commercially available continuously operating device, which measures the content in undried flue gas. Prior to leading the gas into the analyser particles are filtered from the gas.

¹⁾ CEN - (Comité Européen de Normalisation/European Committee for Standardization)

The requirements of efficiency for the boiler classes are as follows:

$$\begin{aligned} \text{class 1} & \quad \eta = 47 + 6 \log Q_n \\ \text{class 2} & \quad \eta = 57 + 6 \log Q_n \\ \text{class 3} & \quad \eta = 67 + 6 \log Q_n \end{aligned}$$

where Q_n is the nominal output of the boiler (kW).

For example, if the nominal output of the boiler is 20 kW the requirements of minimum efficiency in the boiler classes are as follows:

$$\begin{aligned} \text{class 1} & \quad 54.8 \% \\ \text{class 2} & \quad 64.8 \% \\ \text{class 3} & \quad 74.8 \% \end{aligned}$$

Table 7. Emission limits given in the EN 303-5 standard for boiler of different outputs and types

Feeding method	Fuel	Nom. Output kW	Emission limit								
			CO			OGC			Particles		
			mg/m ³ as 10 % O ₂			mg/m ³ as 10 % O ₂			mg/m ³ as 10 % O ₂		
			class 1	class 2	class 3	class 1	class 2	class 3	class 1	class 2	class 3
Manual feed	Biofuel	< 50	25 000	8 000	5 000	2 000	300	150	200	180	150
		50 -150	12 500	5 000	2 500	1 500	200	100	200	180	150
		150 - 300	12 500	2 000	1 200	1 500	200	100	200	180	150
	Fossil fuel	< 50	25 000	8 000	5 000	2 000	300	150	180	150	125
		50 -150	12 500	5 000	2 500	1 500	200	100	180	150	125
		150 - 300	12 500	2 000	1 200	1 500	200	100	180	150	125
Automatic feed	Biofuel	< 50	15 000	5 000	3 000	1 750	200	100	200	180	150
		50 -150	12 500	4 500	2 500	1 250	150	80	200	180	150
		150 - 300	12 500	2 000	1 200	1 250	150	80	200	180	150
	Fossil fuel	< 50	15 000	5 000	3 000	1 750	200	100	180	150	125
		50 -150	12 500	4 500	2 500	1 250	150	80	180	150	125
		150 - 300	12 500	2 000	1 200	1 250	150	80	180	150	125