Emissions of particulate matter and organic compounds from combustion of biomass in domestic heating appliances

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Introduction

Emissions of particulate matter (PM) from combustion of biomass is a severe problem for human health throughout the world (EEA, 2017). It is thus essential to form scientific and yet practical emission measurement standards to improve the abatement also of secondary organic particles from biomass combustion. The upcoming Eco Design Directive will set strict limits on the PM emissions from combustion appliances in the EU for domestic heating, *i.e.* boilers and stoves. However, the methods for determining PM emissions varies. Several standard methods can be used (see Fig 1) where variations (*e.g.* filter temperature) exists within each standard method that will influence the measured PM. In addition, emission of semi volatile organic compounds (sVOCs), which will later form secondary aerosols, are not included in current standard methods. The aim with the present study is to add information on how sVOCs can be included in the standard methods to provide a better estimation on the PM found in the atmosphere, *i.e.* including secondary aerosol formation.

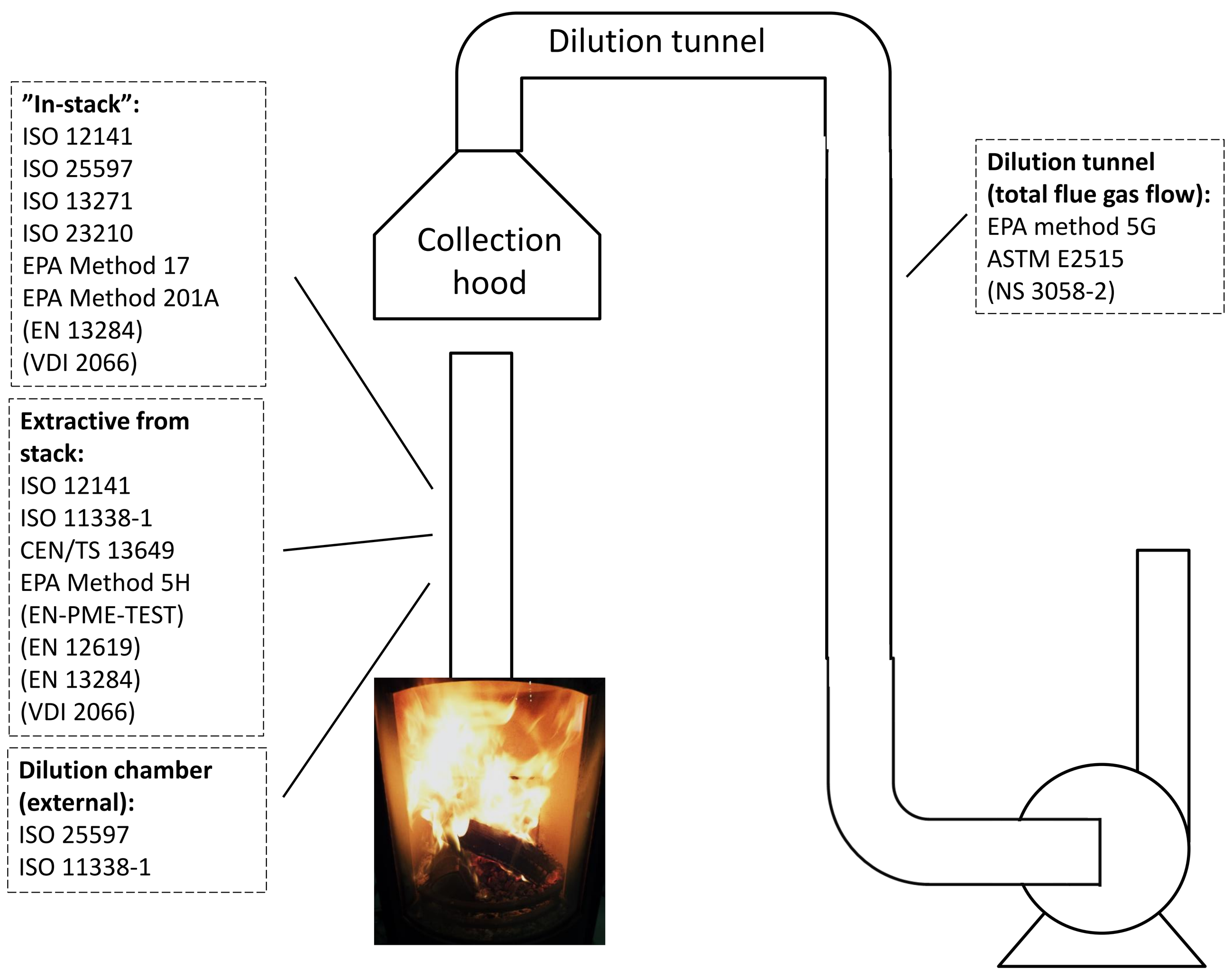

Figure 1. Illustration of the position for different standard methods for PM measurements in stoves and boilers

Method

Combustion tests in RISE lab in Borås, Sweden, of a pellet stove and a wood log stove measuring *e.g.;* PM (in hot flue gas, diluted flue gas, dilution chamber), gases (IR, UV, FID, FTIR,GC-MS) for birch (with and without bark), spruce and standard pellets.

Table 1. Average data for the fuels tested.

	PM-hot [mg/Nm3 @13% O2]	PM-dil. [mg/Nm3 @13% O2]	PM-dil. ext. [mg/Nm3 @13% O2]	THC [mg/Nm3 @13% O2]	Methane [ppm]	Ethane [ppm]	Propane [ppm]	n-Butane [ppm]	n-Heptane [ppm]	Ethene [ppm]	Methanol [ppm]	Formaldehyde [ppm]	Benzene [ppm]	Phenol [ppm]
Birch, no bark	31,6	74,0	34,3	145,3	106,9	1,6	0,1	2,3	0,9	9,6	3,5	16,6	3,3	2,2
Birch, with bark	38,6	62,6	22,6	107,1	46,1	1,9	2,6	3,5	1,4	20,8	25,2	54,3	2,0	13,5
Spruce	37,6	122,0	46	279,7	134,0	1,5	1,3	2,1	4,0	17,8	7,3	34,0	4,2	3,3
Pellets, low load	82,1	240,5	105,5	173,8	9,3	0,8	0,3	1,2	0,4	3,0	1,8	13,5	1,4	0,0
Pellets, high load	30,2	43,8	33,5	33,5	4,4	0,3	0,0	1,4	0,5	1,3	1,1	8,7	0,6	0,0

Results

The average result, for each fuel type is shown in Table 1. The results show that for the cases with higher amount of hydrocarbons there is a larger difference between PM measured in the hot flue gases and in the diluted flue gas, *i.e.* condensable PM are included.

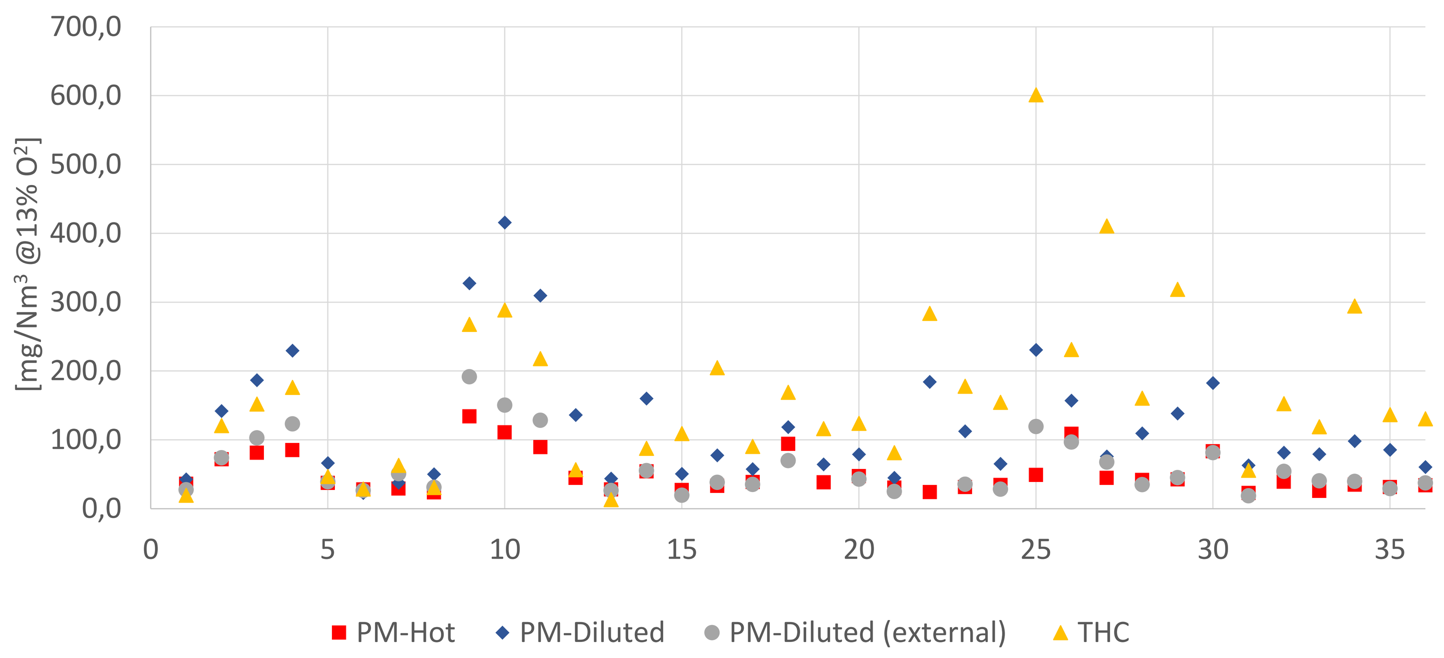

Figure 2. PM and THC concentrations in the stack, dilution tunnel and dilution chamber.

Figure 2 show the measured PM and THC for each test case and there is a correlation between THC and the increase in condensable PM, *i.e.* PM in dilution tunnel, indicating that this relatively simple method can be used to estimate the amount of condensable PM emitted through the stack. Thereby improving the quality of the emission factors from combustion appliances as much of this data is based on standard methods only relying on measurement of hot PM. This sub study will be combined with the results from three other European institutes where the same measurements have been performed, the combined data sets will be used to further explain how the THC information in combination with *e.g.* FTIR data can be used in future emission standards.

Conclusions

- Small differences for hot PM and large differences in the dilution tunnel.
- Adding information on THC, preferably speciated, would develop the standard methods to include condensable PM and precursors for secondary aerosol formation.
- Bark promotes formation of formaldehyde and methanol while methane is lower.

References

EEA, 2017. doi:10.2800/850018

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