IEA Task 32 Workshop: “Highly efficient clean log wood stoves"

Performance of foam ceramic elements in log wood stoves

October 29th, 2015, Berlin

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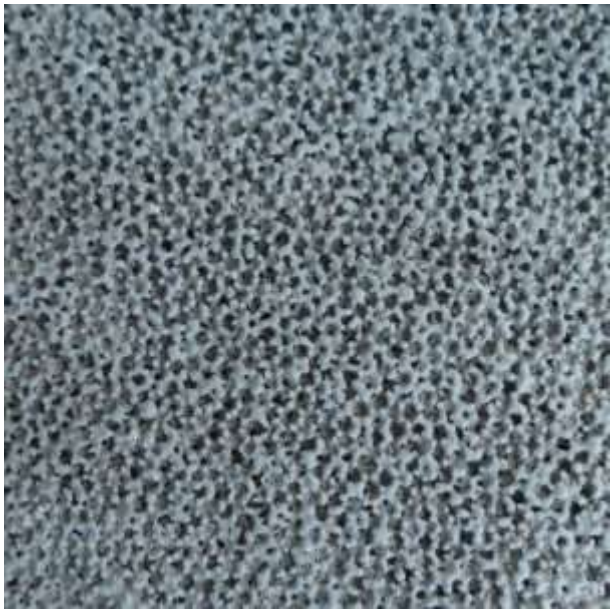
Filter material for measurement of long term feasibility

New foam ceramic

Porosity: 35 ppi

Foam ceramic
after 200 batches



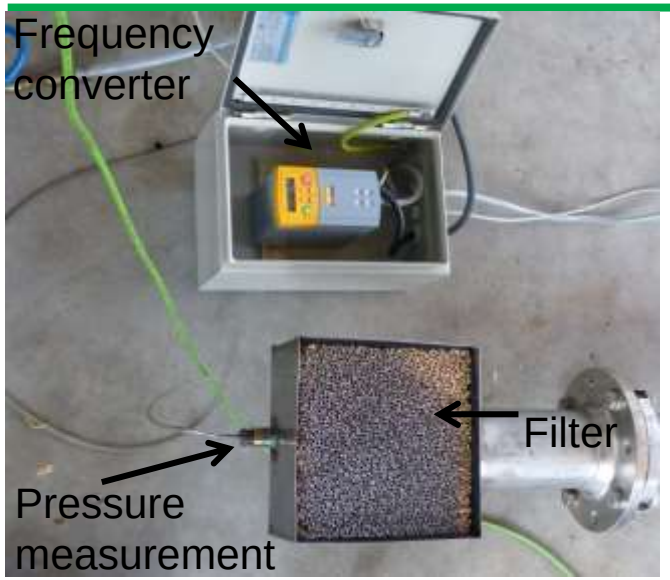
Foam ceramic after
2 heating seasons
Approx. 550 batches
(Filter had been washed after
1st heating season)

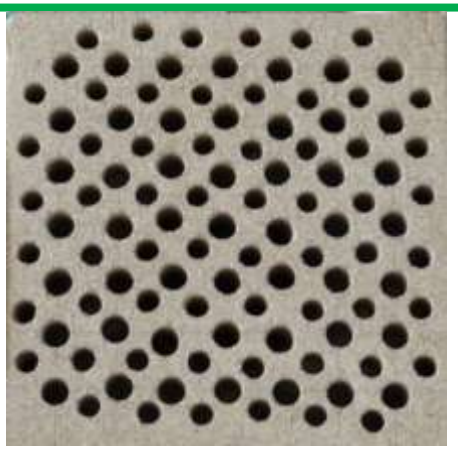
Retrofit catalyst for stoves using foam ceramic filters

Product specification data as declared by manufacturer:

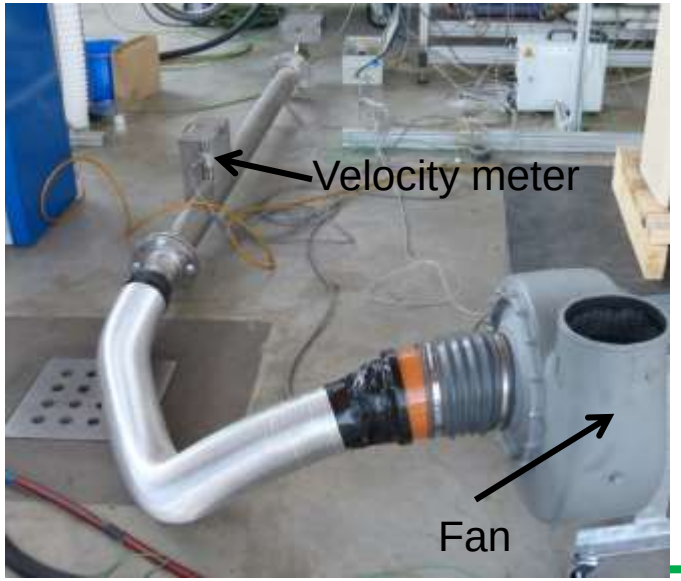
Manufacturer	Linder Katalysatoren GmbH
Thermal resistance	> 1450 °C
Carrier material	SiC- foam ceramic (SiC – SiO_2 + 3 C → SiC + 2 CO and Al_2O_3) (Al_2O_3 components fired at 2300-2500°C)
Coating	Platinum (Pt78), Palladium (Pa45), Rhodium (Rh46)
Reduction	CO, OGC, NO_x, PM
Structure	> 70% open porous surface
Porosity	PPI 8, PPI 10, PPI 20, PPI 30,

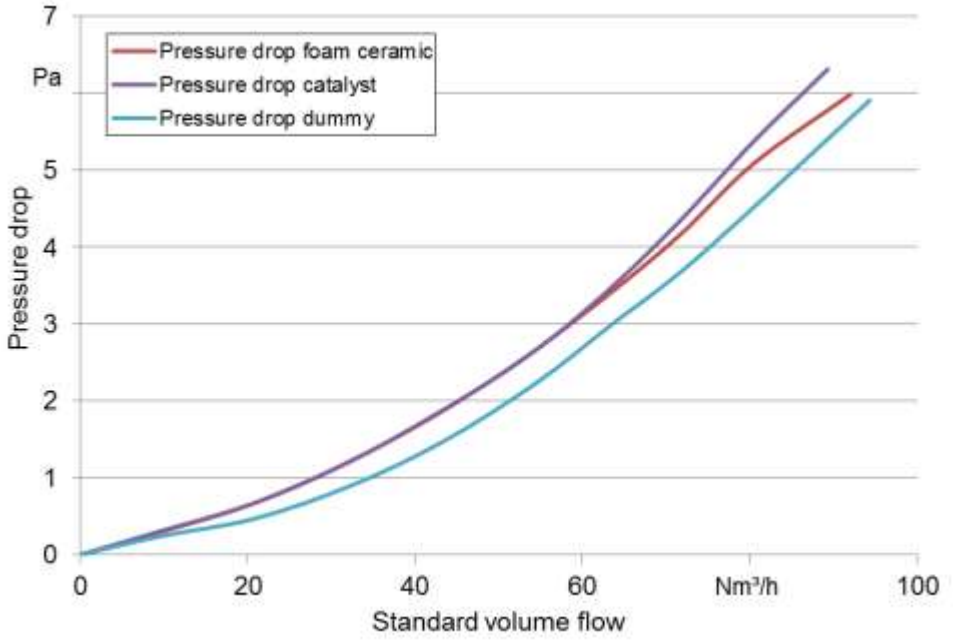
Construction of an equivalent flow reducion (“Dummy”-Filter)



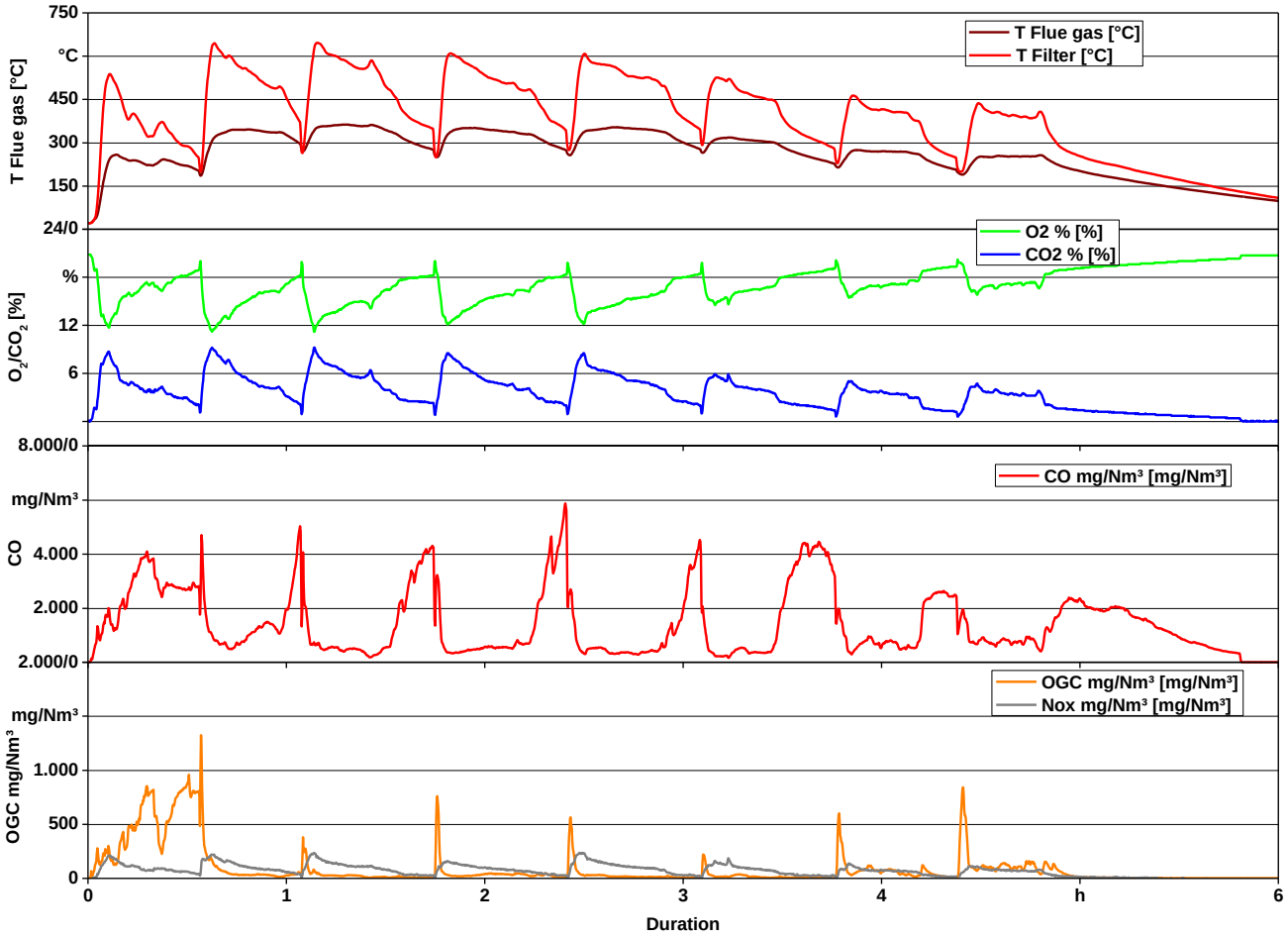


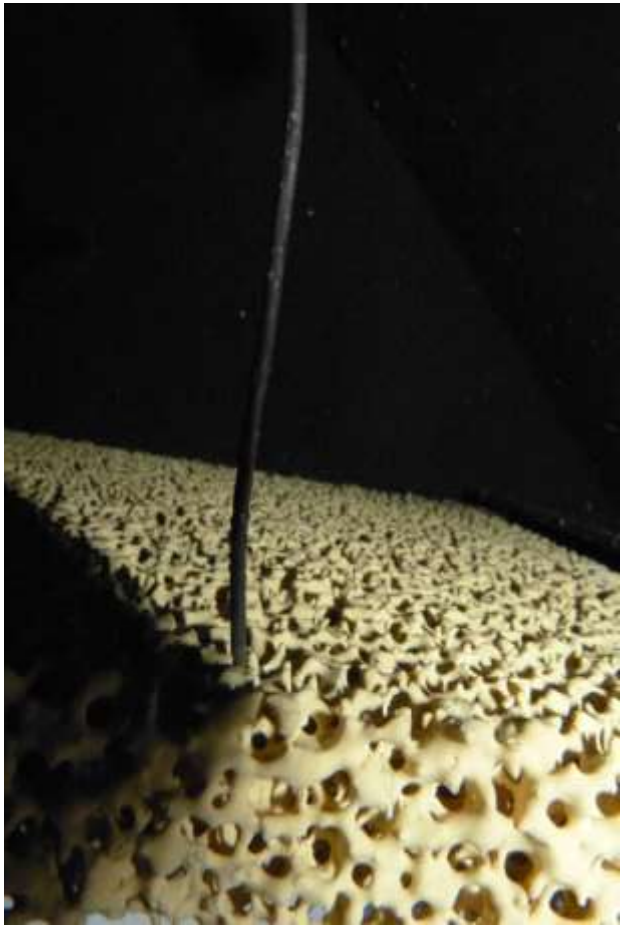
TFZ-Dummy:
Material: Vermiculite (25 mm)
Drill holes: 8 and 10 mm



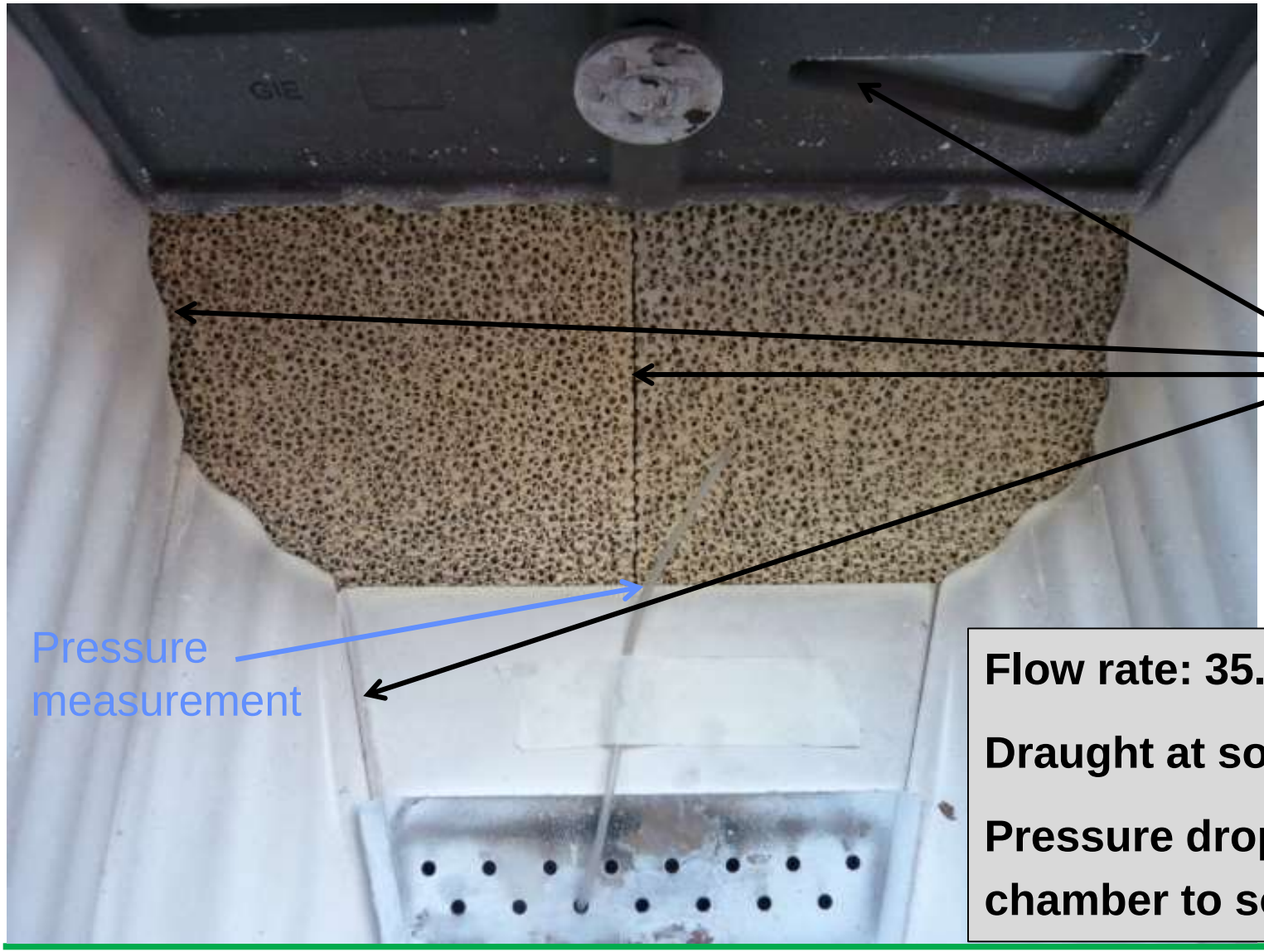


Measurement of filter temperature





Determination of the actual flue gas flow path

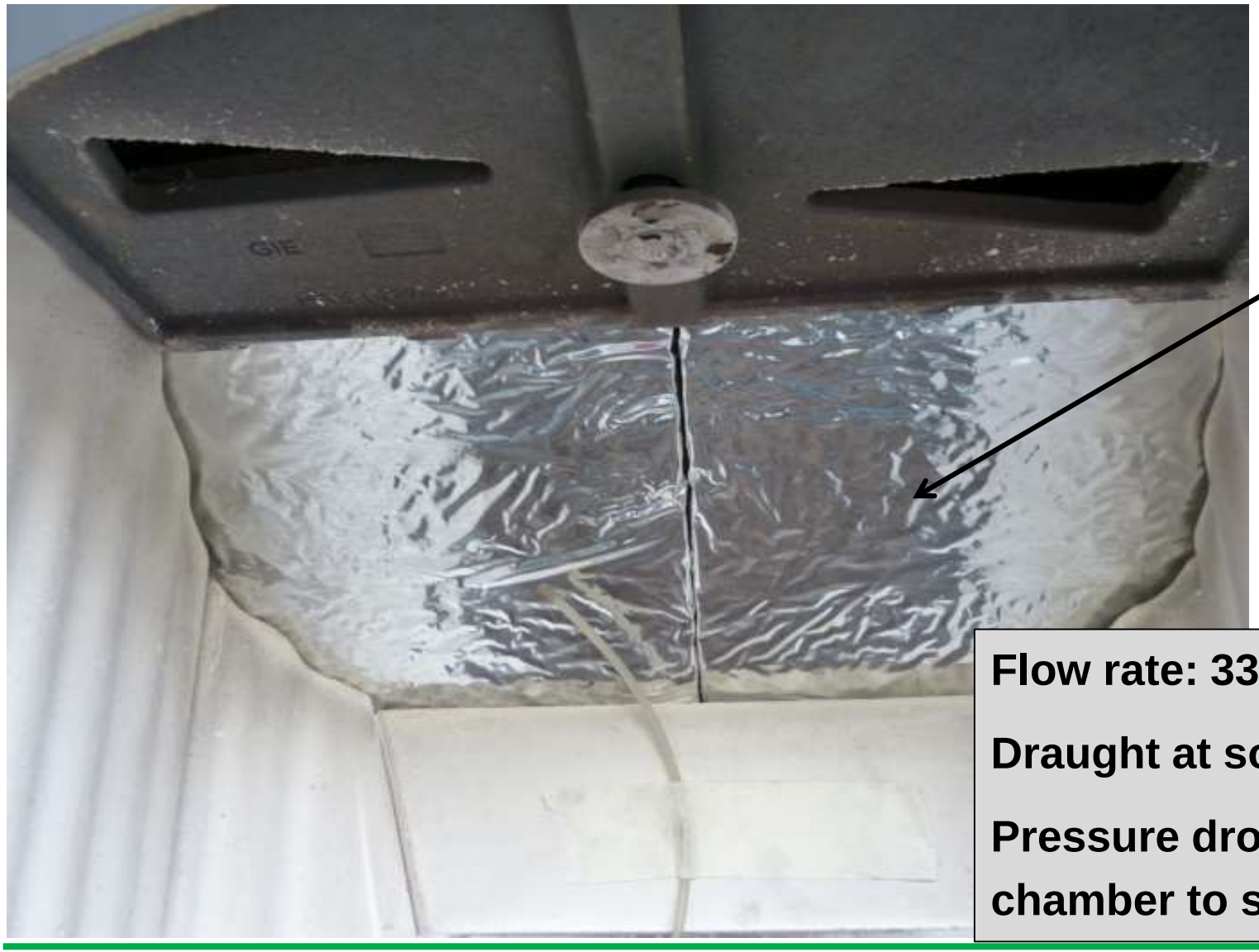


Flow rate: 35.4 Nm³/h

Draught at socket: -11.8 Pa

Pressure drop, burning chamber to socket: 3.2 Pa

Determination of the actual flue gas flow path (2)



1. Masking the filter plates with air tight tape

Flow rate: 33.9 Nm³/h

Draught at socket: -11.9 Pa

Pressure drop, burning chamber to socket: 3,8 Pa

Determination of the actual flue gas flow path (3)

2. Masking all suspected leakages with air tight tape

Flow rate ↓pressure drop ↑

Flow rate = 21.2 Nm³/h

Draught at socket = -11,8 Pa

Pressure drop, burning chamber to socket: 9,1 Pa

Determination of the actual flue gas flow path (4)

3. Cutting the air tight tape from the filter plates

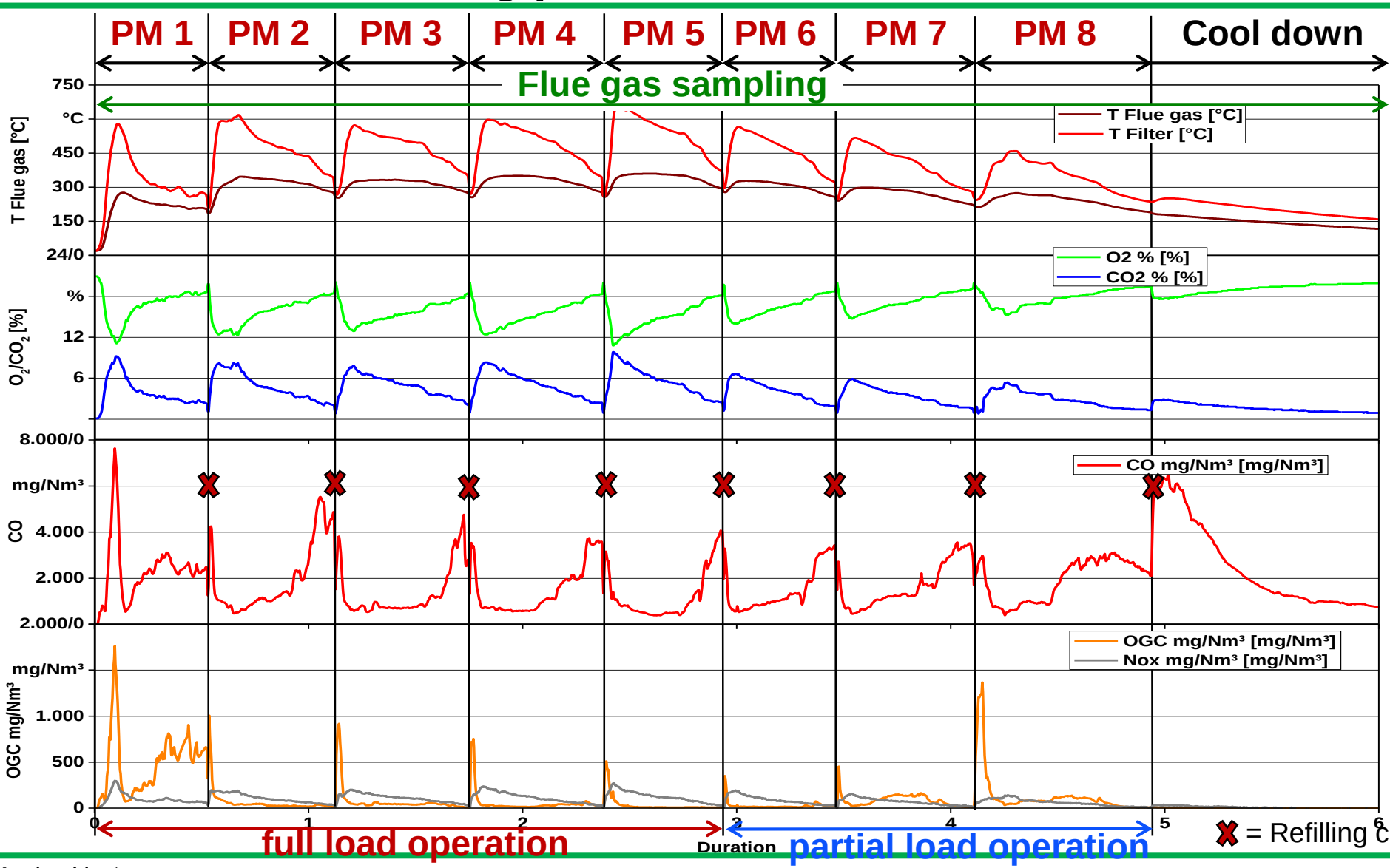
Similar flow rate and pressure drop to variant 1.

Flow rate = 33.9 Nm³/h

Draught at socket: -12.0 Pa

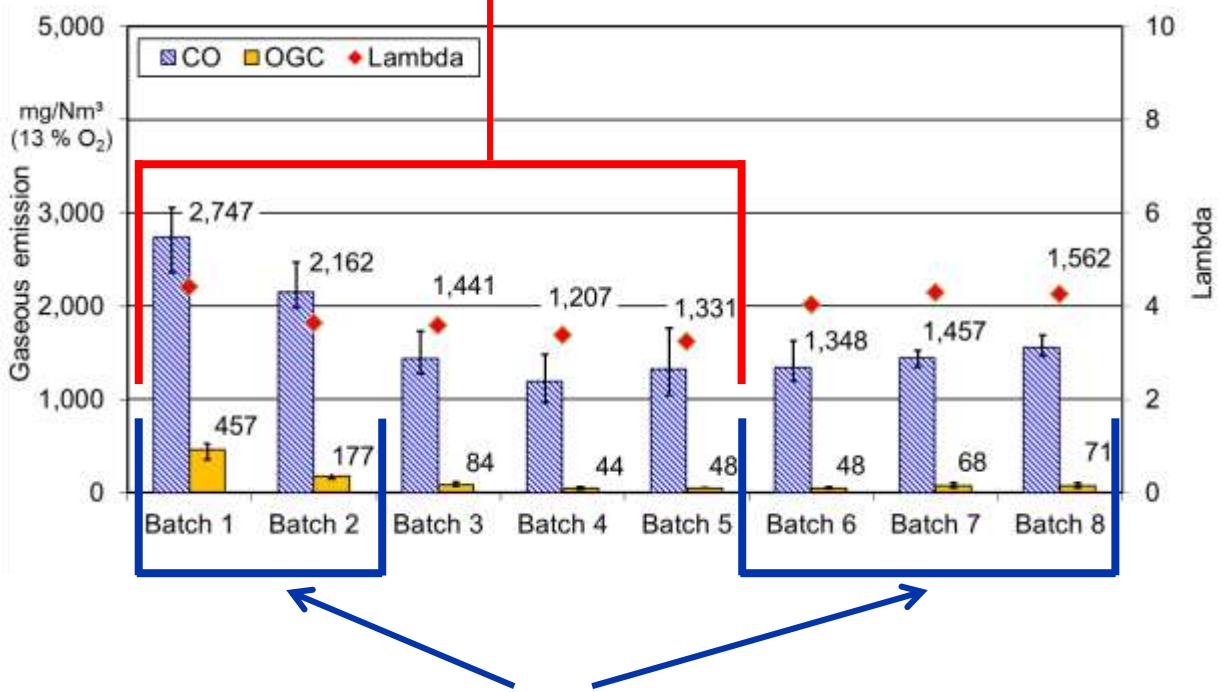
Pressure drop, burning chamber to socket: 3,9 Pa

Flowchart of the testing procedure used



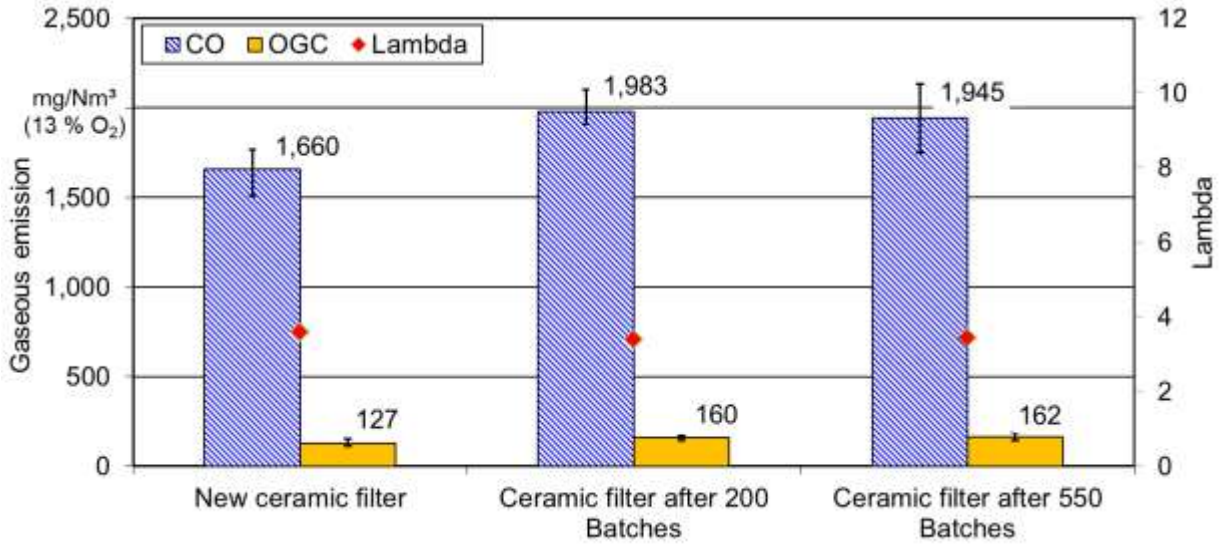
Evaluation of measuring cycle (full load and part load)

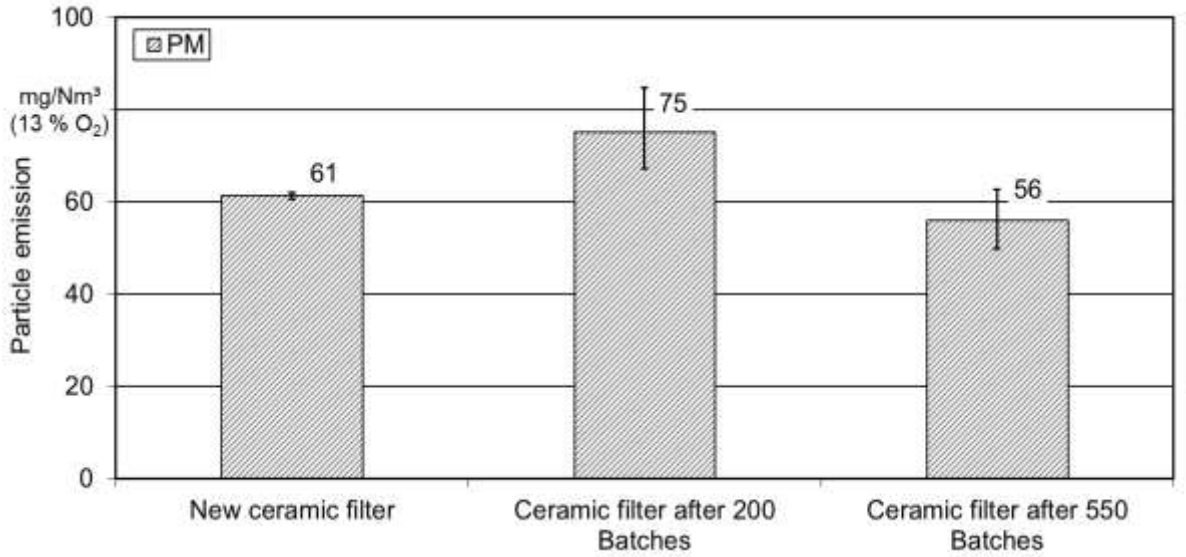
Full load: time weighted average value of batch 1-5



Part load: time weighted average value of batch 1,2,6,7,8

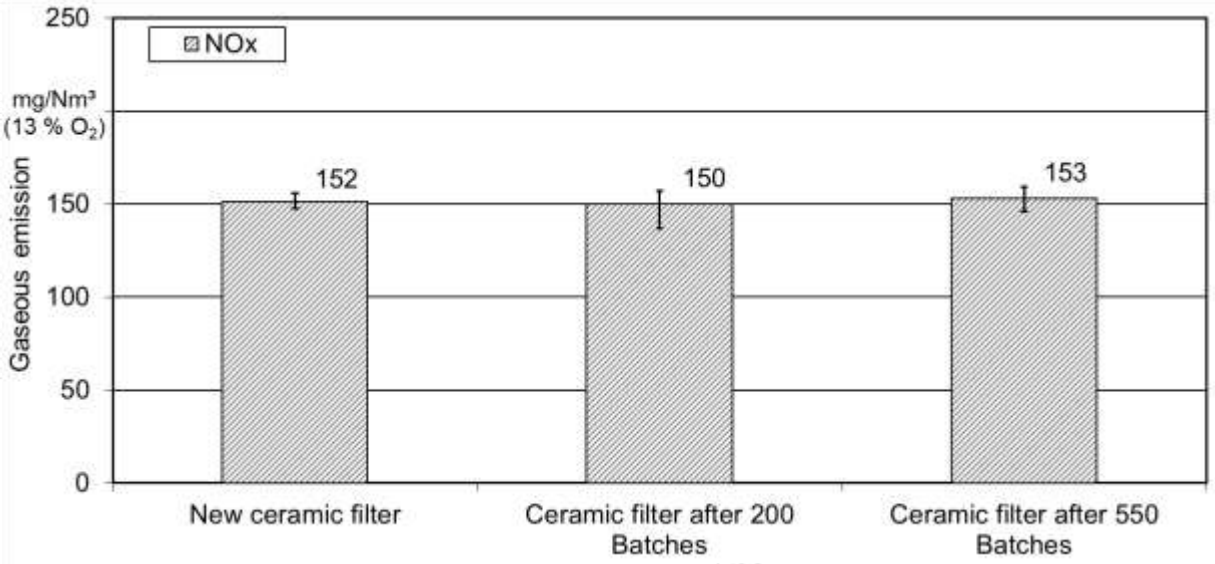
Comparison of foam ceramic filters: Full load cycle (1)

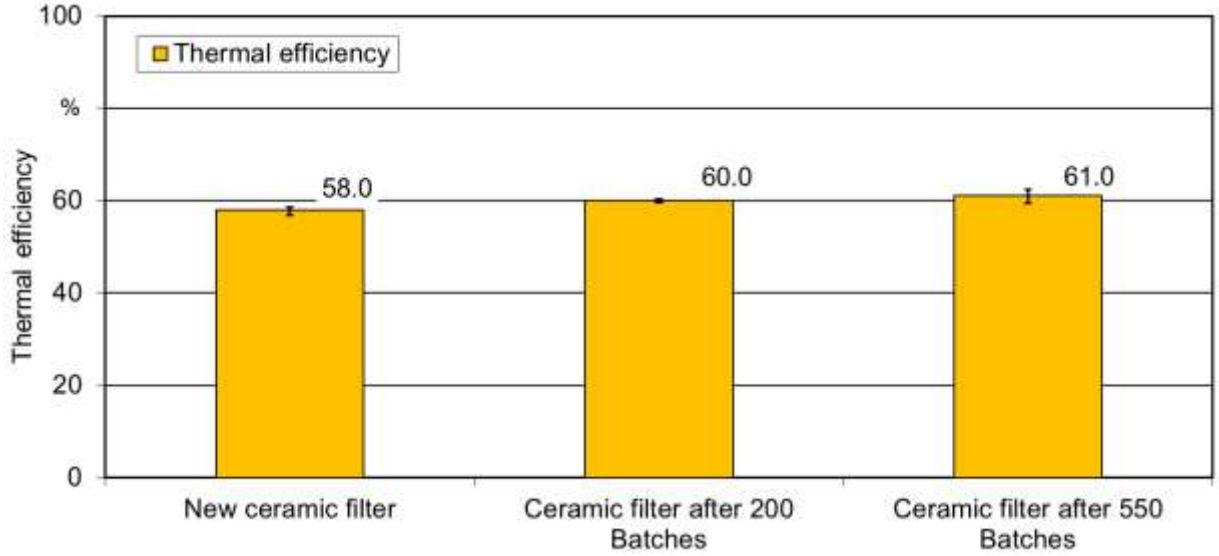




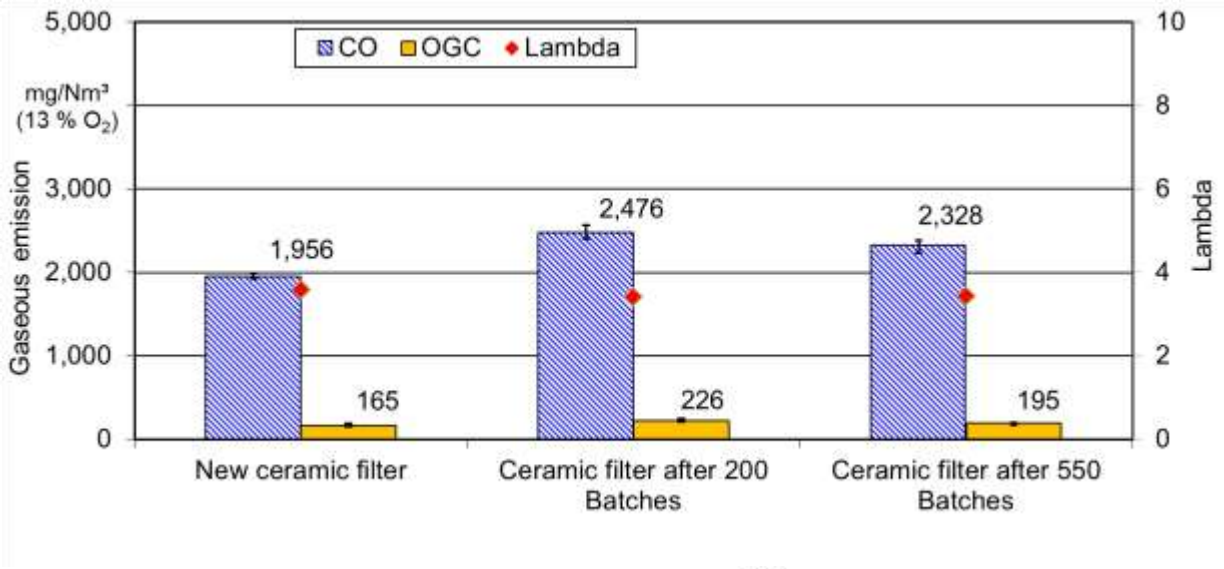
- 3 testing days per filter
- All tests at natural draught
- One weighted average value of batch 1-5
- Same damper settings for all tests
- Test fuel: Beech with bark
- PM sampling starts before refilling and ends before next refilling

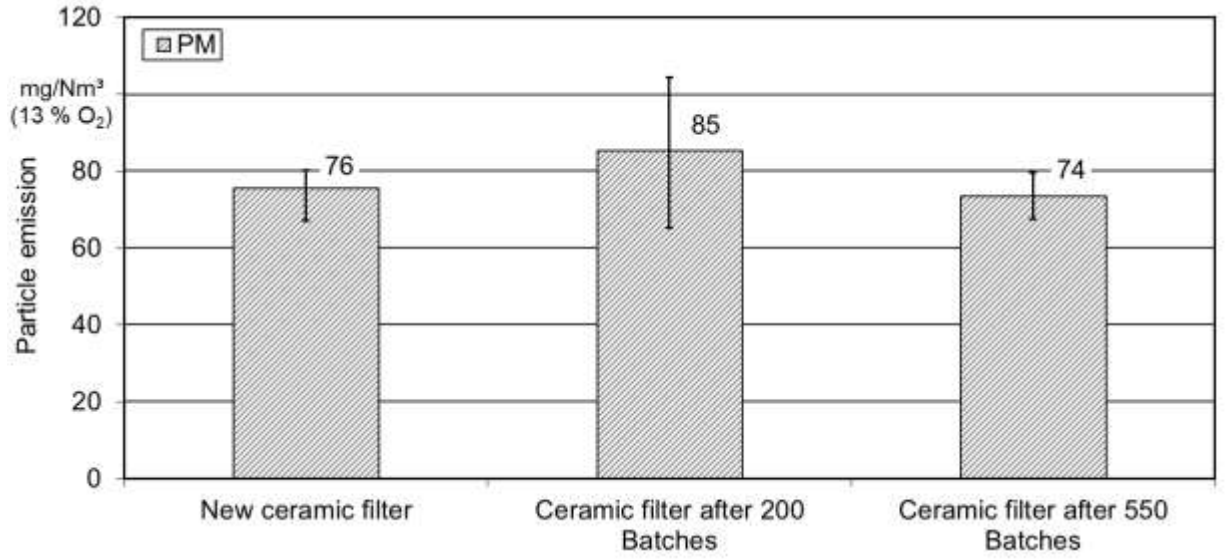
Comparison of foam ceramic filters: Full load cycle (2)





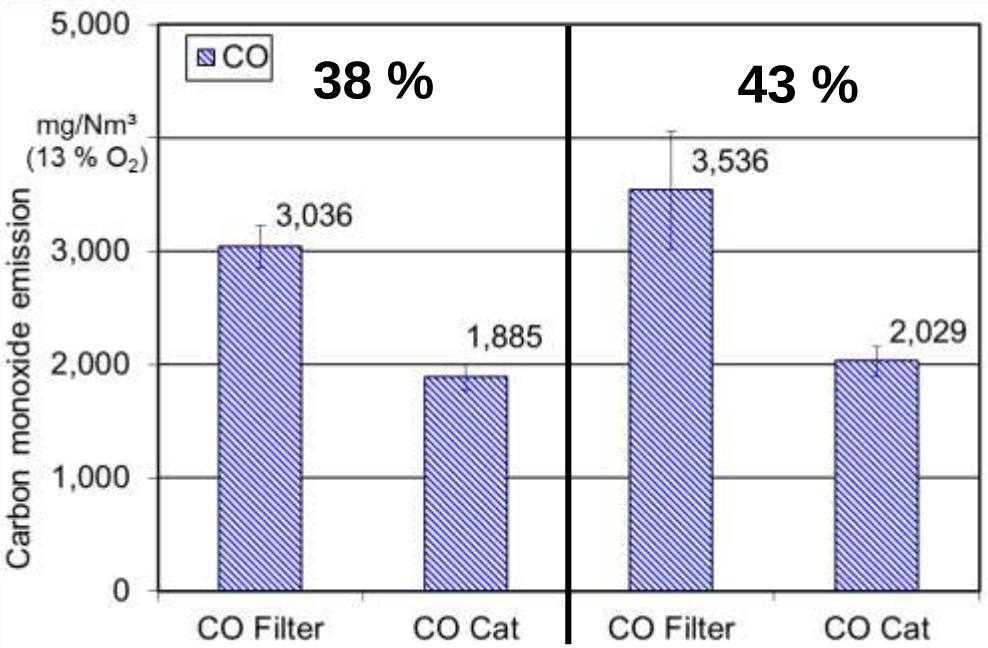
Comparison of foam ceramic filters: Part load cycle (1)



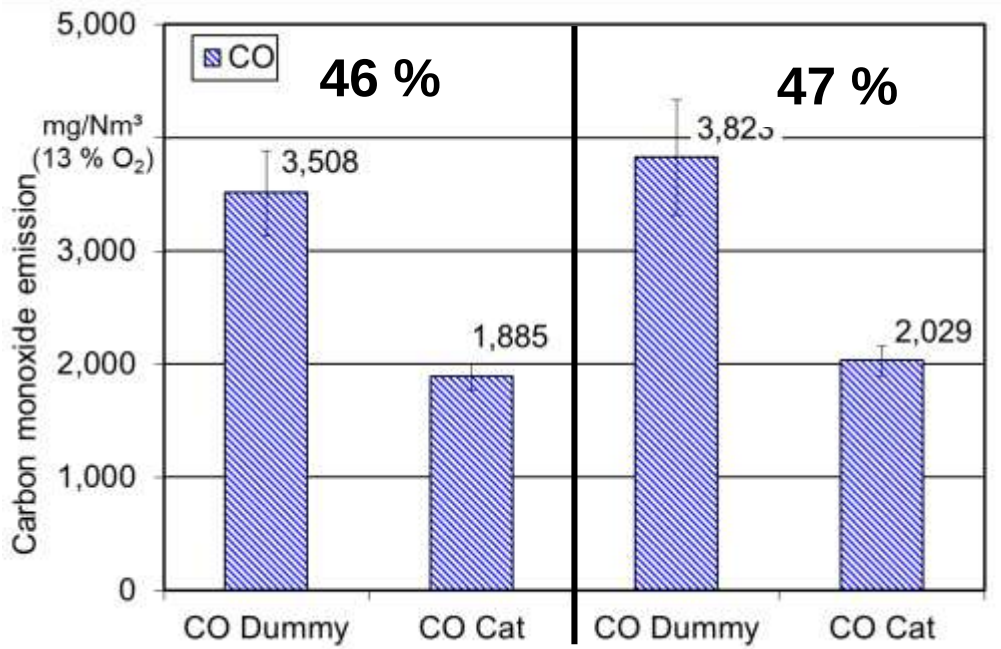


CO conversion

Filter → Catalyst

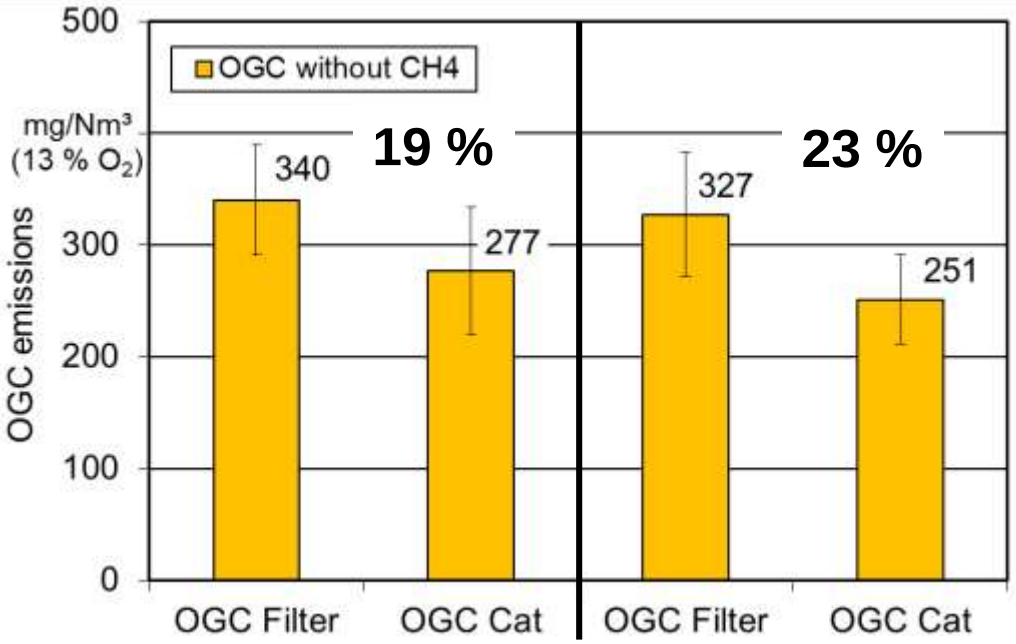


Dummy → Catalyst

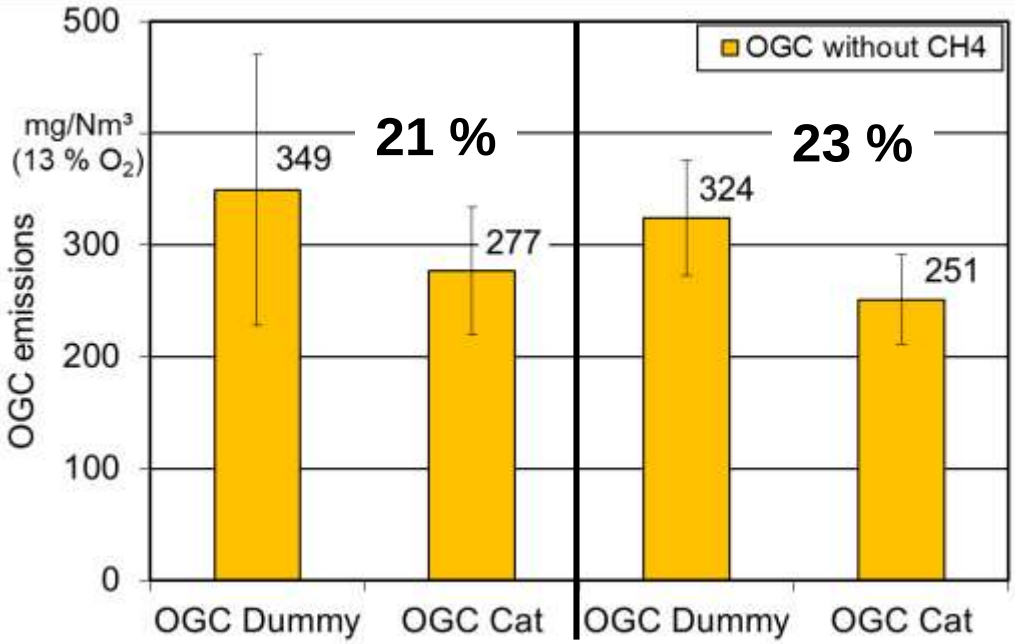


Non-Methane-OGC conversion

Filter → Catalyst

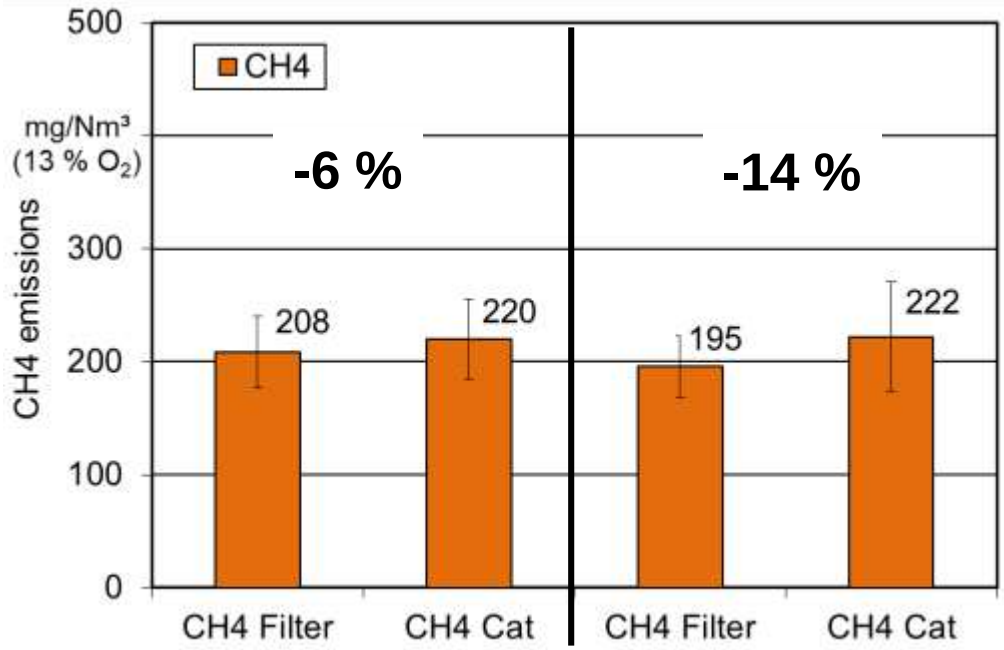


Dummy → Catalyst

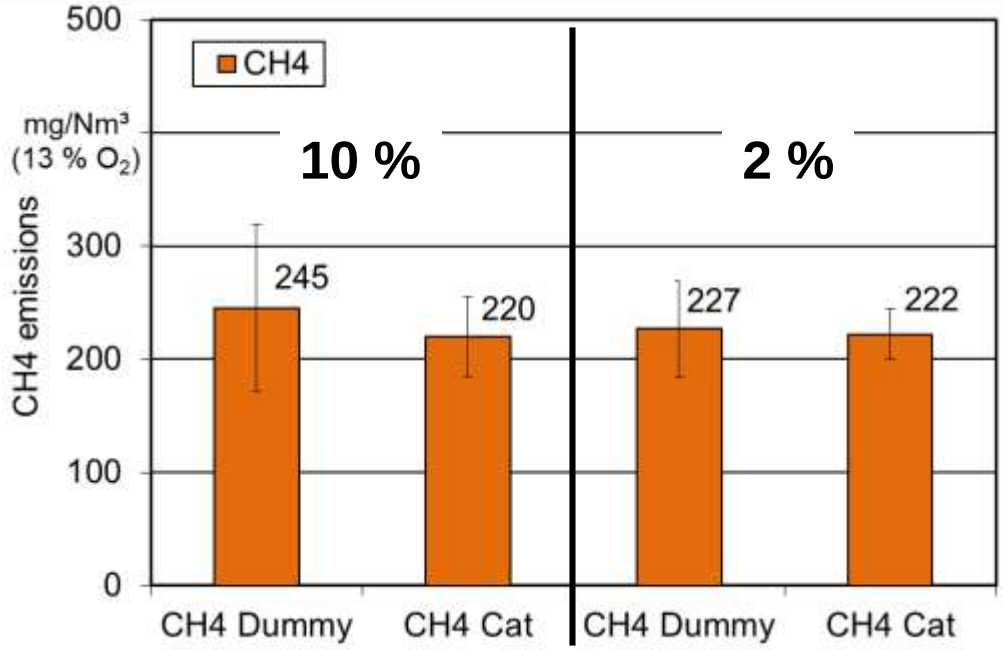


Methane conversion

Filter → Catalyst

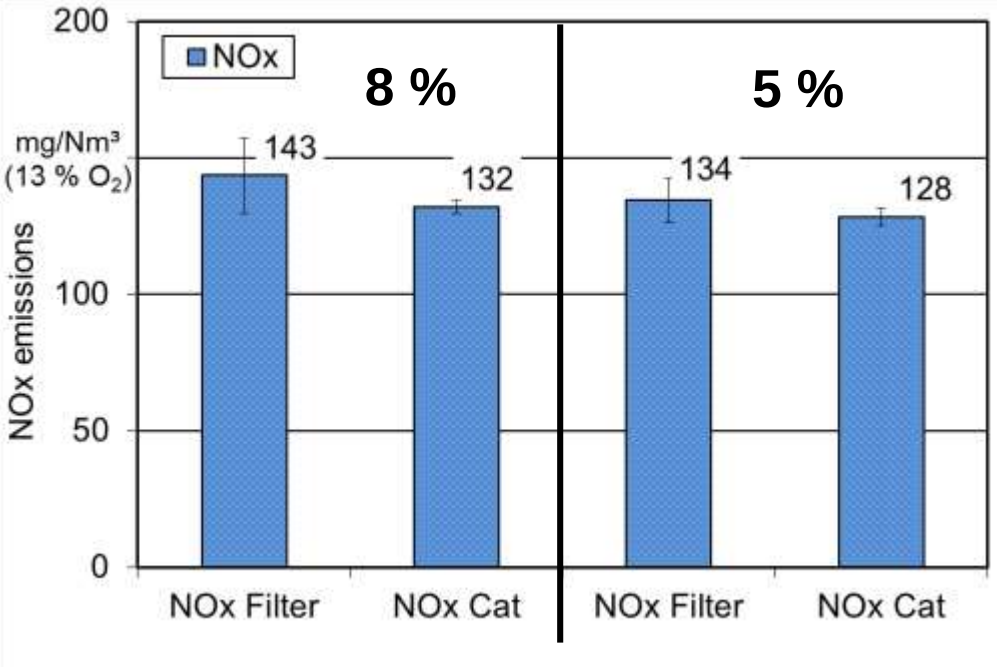


Dummy → Catalyst



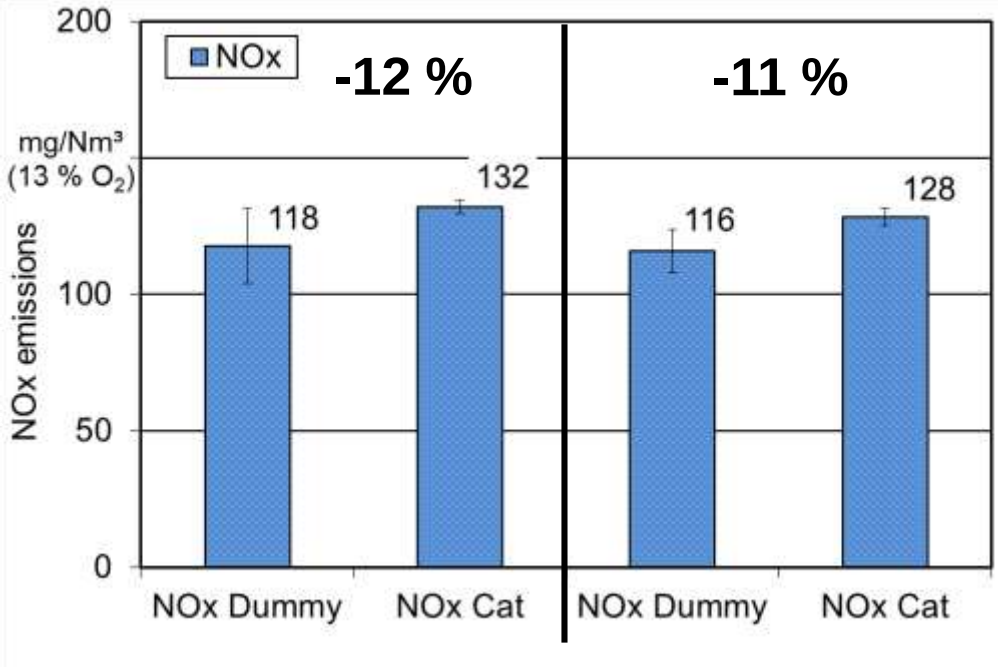
NO_x conversion

Filter → Catalyst



Nominal load Partial load

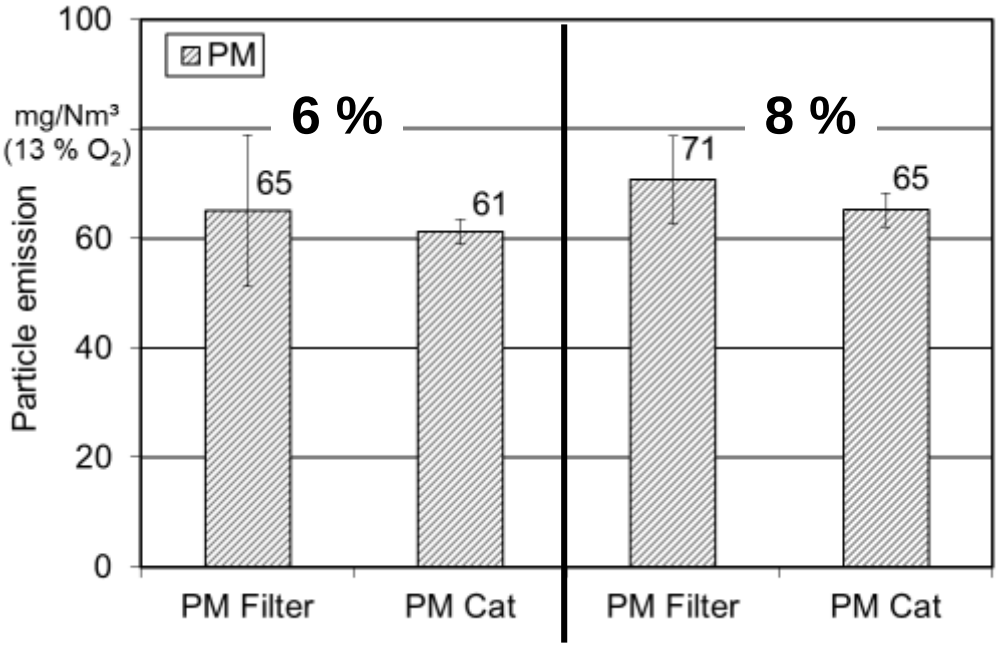
Dummy → Catalyst



Nominal load Partial load

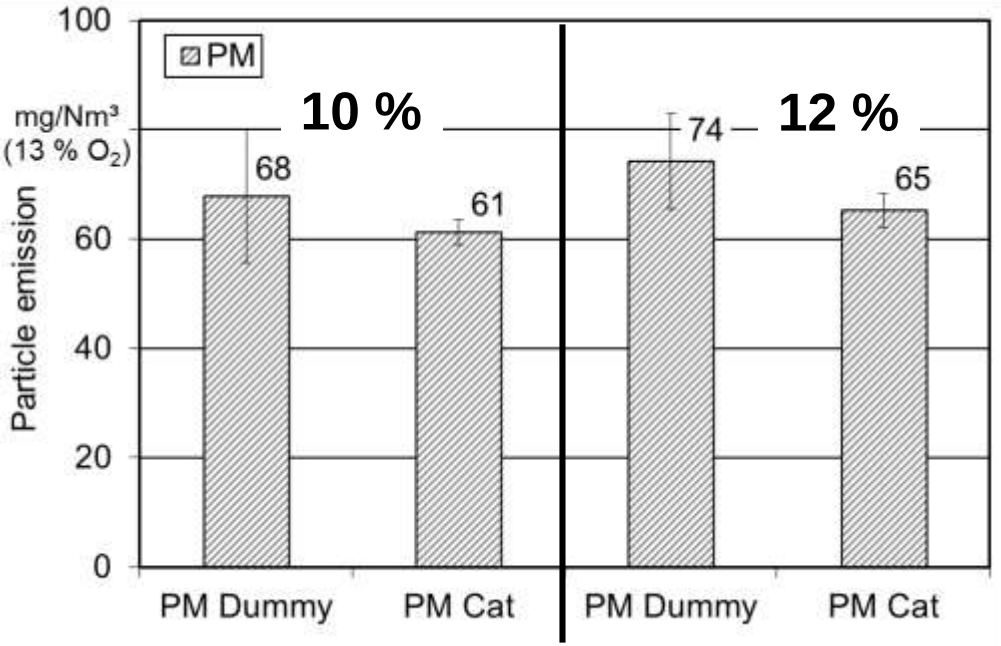
PM reduction

Filter → Catalyst



Nominal load Partial load

Dummy → Catalyst



Nominal load Partial load

Conclusions

- Expectations for PM reductions by foam ceramic elements were not met (particularly for non-catalytic elements).
- Catalytic foam ceramic elements can reduce gaseous flue gas emissions (CO, OGC).
- Log term monitoring of this effect is required (field tests).
- Regarding the flue gas flow through the foam ceramics there is still some potential for optimisation.
- It is desirable to achieve higher surface temperatures (< 700 °C) on catalytic elements.
- Retrofitting of catalytic foam ceramic elements may be an interesting option.

Thanks for your attention!

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