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EN-PME-TEST

Determination of particulate matter emissions from solid biomass fuel burning appliances and boilers - Proposal for a common European test method

Workshop: IEA Bioenergy TASK 32, Graz, Austria

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Content

- EN-PME-TEST Project overview
- Technical details of the proposed PME-measurement method:
  - Basic layout of PME-sample train
    - Probe
    - Nozzle orientation
    - Probe deposits
  - Improvements for the probe design
- Results of intercomparison trials
- Outlook on new approach by Total Carbon Measurement

Regulation and standardisation

- European Commission Regulation (ECR) for ecodesign
  - Standardization request to various CEN/TC to revise existing EN to harmonised standards to be in line with new ECR
    e.g. ECR 2015/1185 (solid fuel local space heaters)
    (actual EN has 3 methods for PME measurement)
- Standardisation request:
  - just one PME measurement method instead of the actual 3
    (heated filter, dilution tunnel, electrostatic precipitator)
    ➔ EN-PME-TEST
  - test protocol shall reflect real life operation ➔ BeReal-project
- CEN TC 295 WG5 : many years trying to agree on a common measurement method, all attempts have failed so far

EN-PME-TEST-Project (2012–2015)

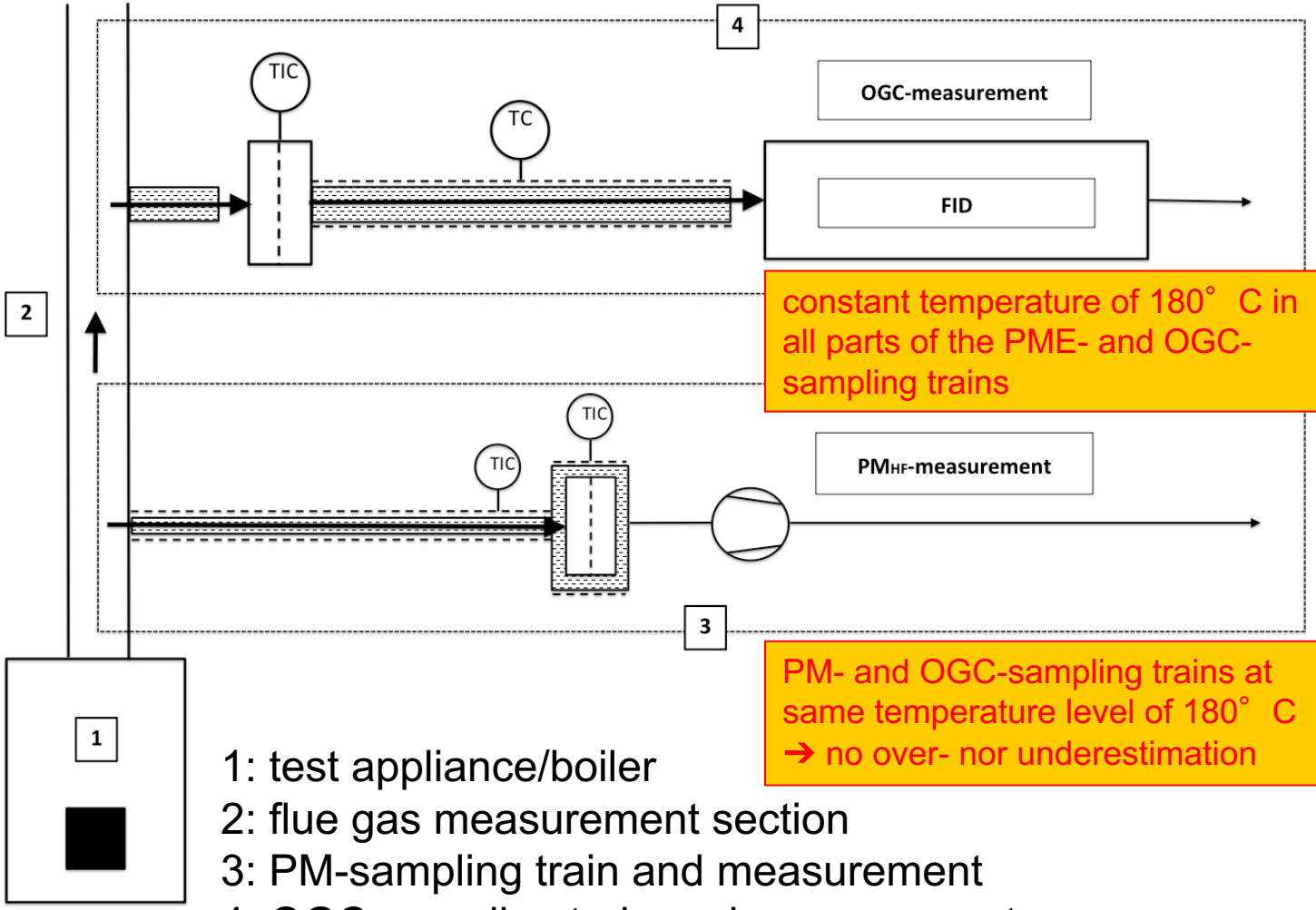
- Under the Umbrella of the **ERA-NET call**
- **Co-normative research project** to establish a scientific basis for a test method to determine solid and condensable particle emissions from residential heating appliances and boilers burning solid fuel.
- **17 partners from 10 countries**:
- **Research institutes, universities, notified bodies** : strongly involved in standardisation activities (TC 295 WG5), closely connected to authorities and industrials



Requirements for a new PME-test method

- Low investment costs for the test laboratories
- Low limit of quantification (LoQ) due to low threshold limit values (TLV) in upcoming regulations (EC-ecodesign)
- Comparability to existing standards reference method assessed, or tested against reference materials, uncertainties determined
- Take into account particles with diameters down to 10 nm (effect on human health)
- Take into account the fraction of volatile organic compounds
- Primarily intended for use in test laboratories and for products developments; option for field inspection
- Operation procedures according to actual test protocols (firing procedures not investigated)

Layout of Short Term Method



constant temperature of 180° C in all parts of the PME- and OGC-sampling trains

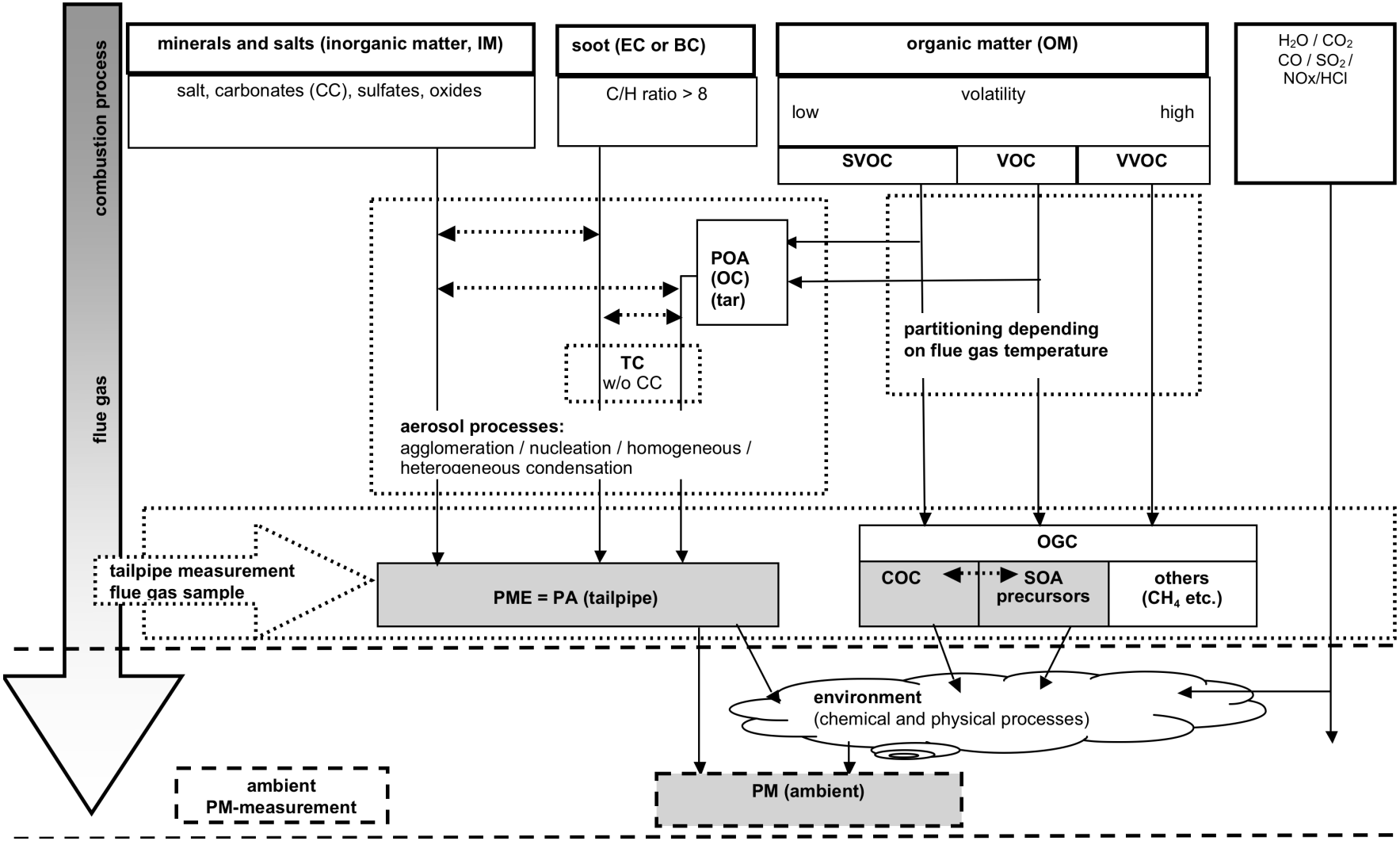
PM- and OGC-sampling trains at same temperature level of 180° C
➔ no over- nor underestimation

1: test appliance/boiler
2: flue gas measurement section
3: PM-sampling train and measurement
4: OGC-sampling train and measurement

Basic concept for improved traceability

- The new method determines the emissions "as pure as possible" to improve traceability:
  - minerals and soot on heated filter
  - OGC in the gas phase by FID
- The higher the sampling temperature, the lower the amount of condensed organic components in the particle phase.
- Sampling temperature is limited due to PTFE components in sampling line and due to standard FID temperature levels.

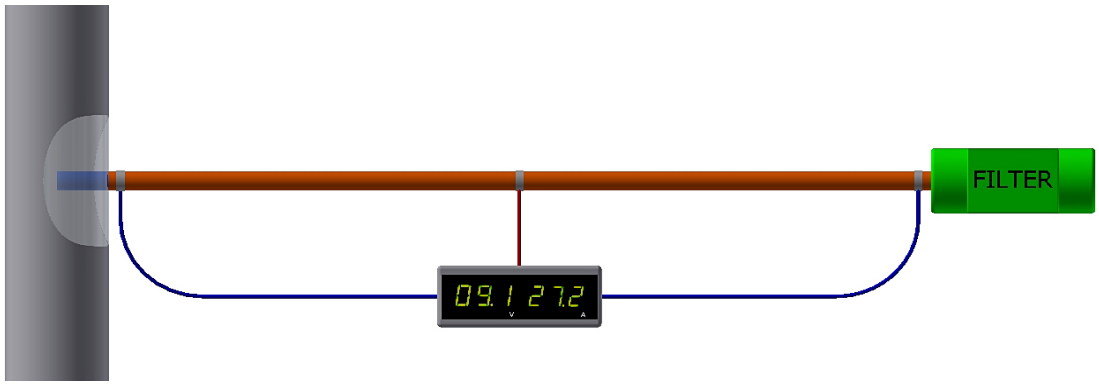
PME-formation pathways in combustion



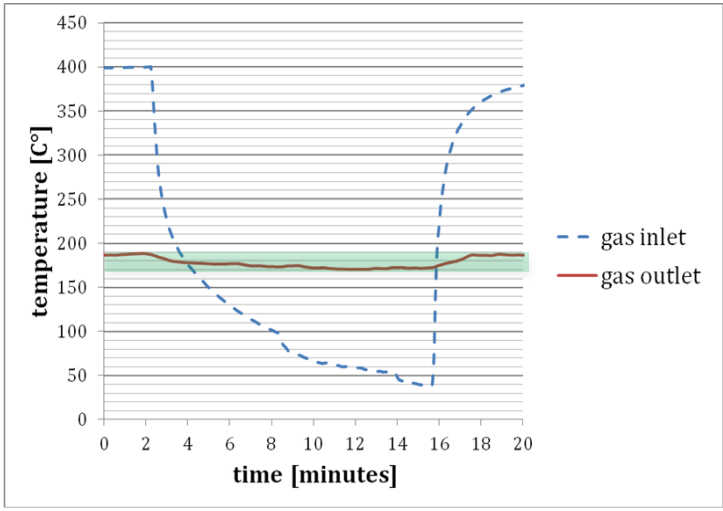
Basic layout of PME-sample train

- **Probe** has to guarantee the design temperature of 180° C+/-10 K of the sample gas the end of the probe as well as at its inner surface.
- **Nozzle orientation** is set perpendicular to flow direction (90° -nozzle orientation) in order to increase the repeata-bility of PME-measurement by separation of larger particles (randomly coarse or re-entrained particles in flue gas). This setting is more in line with ambient particle measurement with particle size sampling below 10 µm (PM10).
- **Probe deposits**
  - Taken into account (contrary to DIN+ method)
  - Directly added to gravimetric filter by blowing probe after each run, instead of rinsing and allocation at the end of the test day (as defined in EN13284-1).

Resistive heating for optimal thermal characteristics of probe

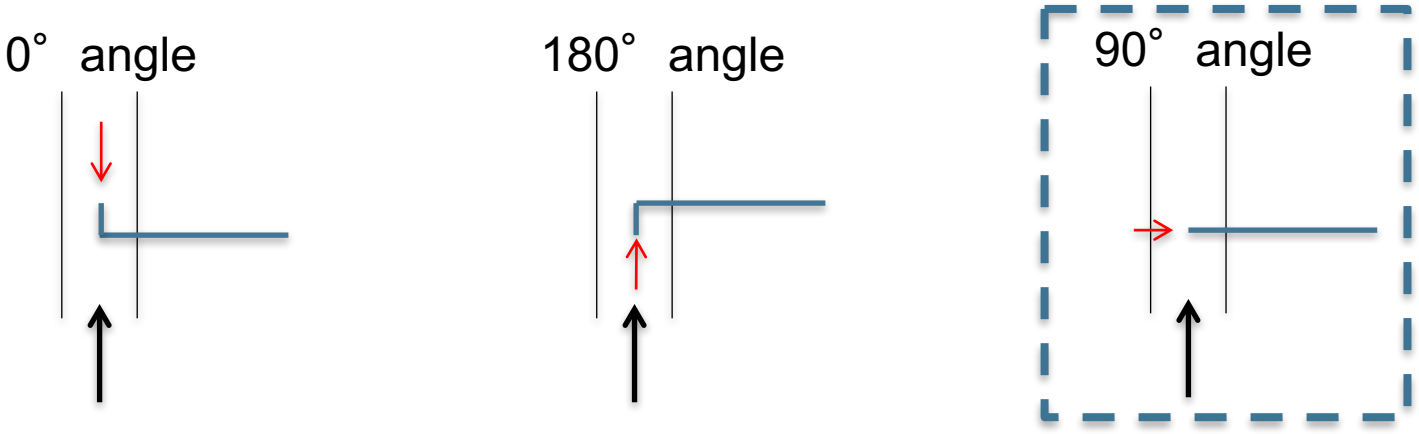


- Direct electrical heating (probe-tube is resistor)
- Completely heated section between stack and filter casing
- Probe heated at 180 ° C with a total length of 2 meters allows a constant gas outlet temperature of 180° C±10K for inlet temperatures from 40° C to 400° C.



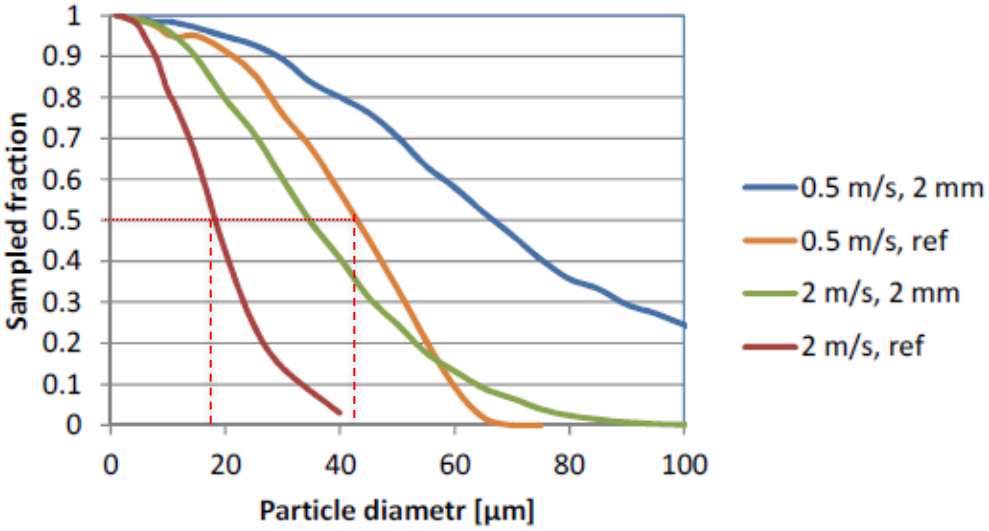
Sampling velocity and nozzle orientation (I)

- Low flue gas velocity in flue gas duct (generally below 2 m/s) makes precise isokinetic sampling impossible.
- Variable amount of large, randomly re-entrained particles in the flue gas under tarry and sooty combustion conditions makes isokinetic sampling less reproducible.
- A simple manner for systematically removing coarse particles is using a 90° angle of the sampling gas flow.



Sampling velocity and nozzle orientation (II)

- With a flue gas velocity in the duct of 2 m/s and using a 0° or 90° -angle it is possible to remove coarse particles (larger than 20µm, according to the CFD calculation). The graph shows the fraction of particle collected according to sampling conditions.



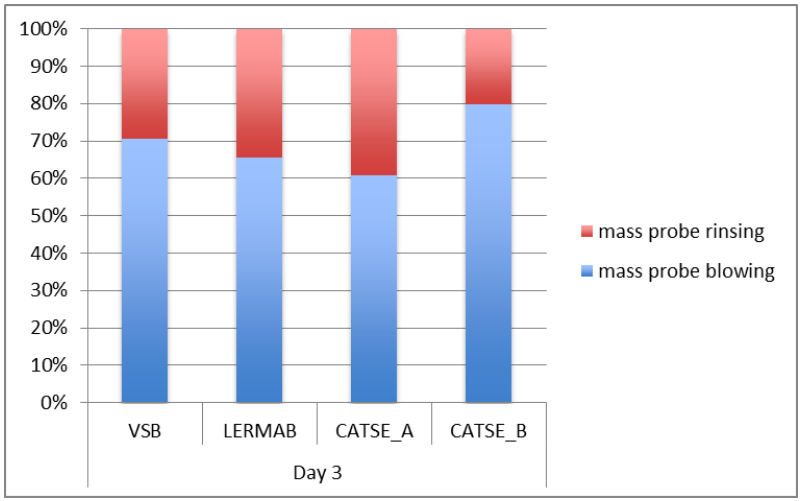
Particle collection efficiency obtained using reverse sampling according to flue gas velocity in the duct (0.5 m/s and 2 m/s) and nozzle diameter (ref stands for 8 mm nozzle diameter) at a sample rate of 10 l_{stp}/min

Deposits in the probe (I)

- The amount of deposit determined by probe rinsing was comprised in most cases between 5% and 30% of the PM mass on filter.
- Determination of the amount of dust deposited in the probe remains necessary particularly when using a two meter probe (not taken into account in DIN+ or EN16510-1).
- Rinsing is quite an elaborate and error-prone procedure .
- In wood combustion the amount of deposit in the probe is not linked to the level of PM in the flue gas. Therefore rinsing the probe at the end of each day of sampling and allocate the deposits according to the amount of dust collected on each filter (En13284-1) is not a sound procedure for wood combustion.

Deposits in the probe (II)

- New approach of blowing into the probe using com-pressed filtered air and transport the deposits onto a weighed and conditioned filter placed in the filter holder after each test.
- Deposits in the probe represents no more than 30 % of the total mass of PM collected – therefore the use of blowing allows collecting about 90% of the total mass.



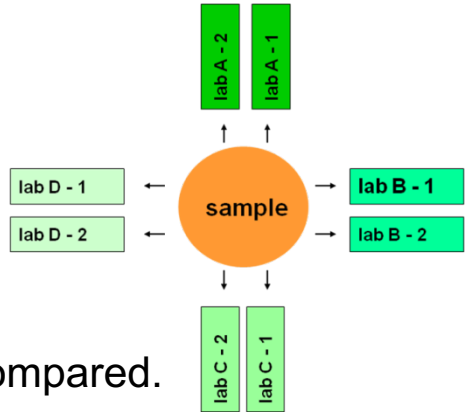
Contribution of deposit in the probe determined by rinsing and blowing. More than 60% of the total deposits are removed by blowing.

Improvements for the current probe design

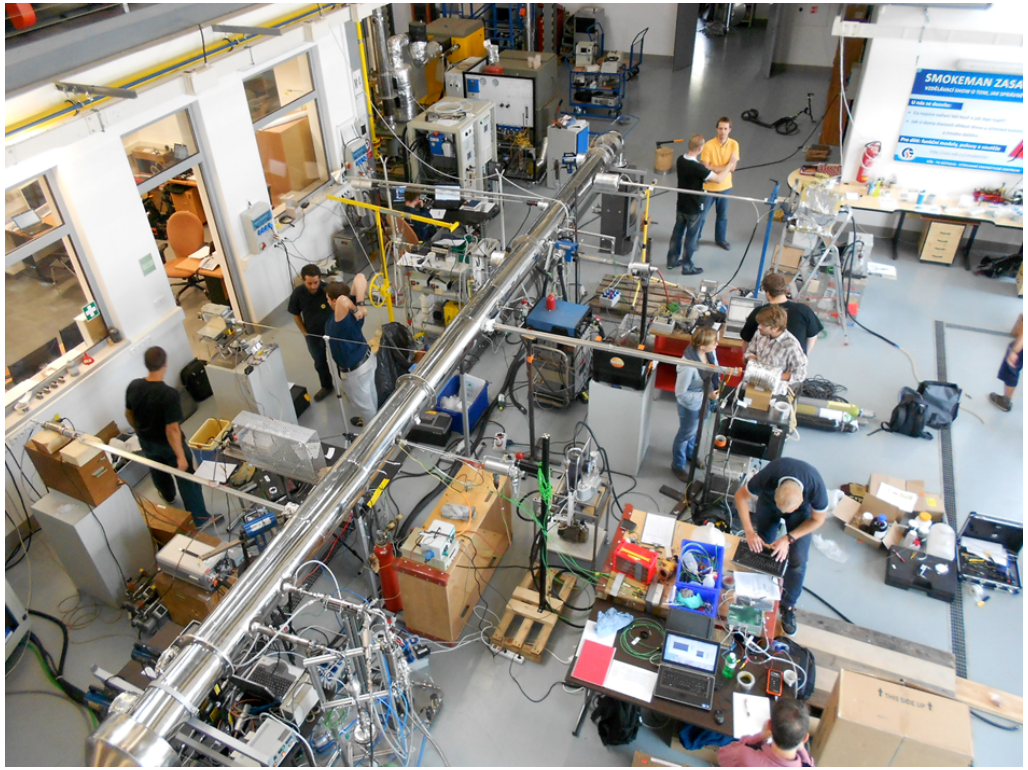
- Probe geometry
  - length can be reduced in certain measurements setups with low flue gas temperature
  - various shapes (trumpet, coiled, etc..) to be investigated
- Standardization of blowing to determine the deposits in the probe
- Prototyping in co-operation with recognized instrument suppliers

Intercomparison tests

INERIS (France); VSB (Czech republic)



- Principle:
  - Sample provided to several laboratories and results obtained compared.
  - Calculation of the global uncertainty of the method (ISO5725-2)



Outcome : Uncertainties determined by intercomparison tests

- Expanded uncertainty for PM (particulate matter collected on the heated filter) :
  - 34 % for PM in the range between 6 and 42 mg/m^3 STP determined on pellet/woodchip boiler
  - 35 % for PM in the range between 41 and 104 mg/m^3 STP determined on wood log stove

  First ever determination of uncertainties on PM measurement methods performed on real sources using simultaneous measurements

- Expanded uncertainty for OGC (FID measurement) :
  - 30 % for OGC in the range between 16 and 144 Ceq mg/m^3 STP.
  - slightly higher than expanded uncertainty obtained by stationary sources emission control labs (INERIS data: expanded uncertainty between 12.5% and 25 % in the range comprised between 5 and 15 Ceq mg/m^3 STP)

Conclusion

- One method combining PM collected on a heated filter and OGC measurement using FID selected and proposed for a common European test method
- Two intercomparisons of methods performed, expanded uncertainties determined
- More technical information on the method available in Project Position paper
- CEN TC 295 WG 5 meeting March 2016 agreed to support the proposed common method

Outlook: Long Term Method

Micro Smog Chamber and Total Carbon Measurement

- Measuring only the particle-bound carbon atoms by means of a total carbon (TC) analysis
- Potential for secondary organic aerosol (SOA) formation must be included by micro smog chamber (MSC) treatment
- TC analysis is already well established for ambient pollution monitoring (good metric for comparing PM-emissions against ambient PM-measurements)
- Better marker for toxicity compared to total PME

MSC combined with TC measurement is a promising option for the future

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