Developments in CEN Particulate Matter (PM) Standards

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Overview of presentation

(1) The mechanics of manual PM measurement and the evolution of CEN standards

- sampling inlet
- filter weighing / filter material

(2) A broader view

The measurement

PM_{10} :

total mass per unit volume of air of particles with aerodynamic diameter below 10 µm (units µg/m³)

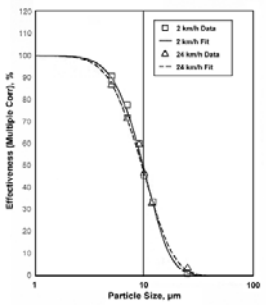
Size selective sampling onto a preweighed filter

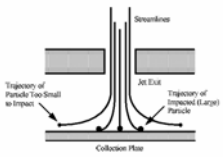
Weighing the sampled filter

Early emphasis (up to 1990s) - sampling

- Concentrations were higher
- More primary, non-volatile material
- Scientific understanding was lower

Particle size convention



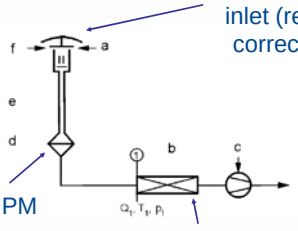


Size selection by impaction

$$d_{cut} = \sqrt{\frac{\eta \cdot 9 \cdot \pi \cdot \eta \cdot d_{jet}^3 \cdot Stk}{4 \cdot C \cdot \dot{V} \cdot \rho_p}}$$

PM_{10} reference samplers (EN 12341 - 1999)

Size selective inlet (requires correct flow)



Collection of PM on filters

Flow control (for correct size selection and known sampled volume)

Standard sampling inlets:

EN 12341:1999 (PM_{10}) – 3 designs

(WRAC, “Hi-vol”, “KFG”)

EN 14907:2005 ($PM_{2.5}$) – 2 designs (“Digitel”, “KFG”)

EN 12341 (PM_{10} revision) – (probably) 1 design

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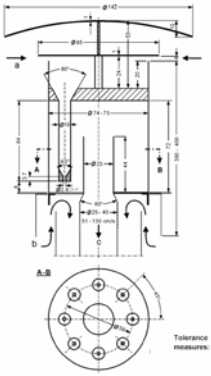
Inlet design convention



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Sampling inlets summary:

Standardisation issues are solved by defining one inlet

Scientific issues remain

Comparability of other inlets is combined with other factors within “equivalence”

Flow control is a related issue that is not addressed in this talk

Emphasis has moved to other factors

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Recent emphasis - filter mass measurement

Typical basic parameters

Mass of 47 mm filter: 100 mg

Mass of PM: 0 – 2 mg

Acceptable uncertainty in Δm: 20 µg

ie 0.02% change in the filter mass

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Some factors affecting particle mass measurements

- Effect of humidity on filter material
- Effect of humidity on PM
- Loss of filter material
- Effect of temperature during sampling, storage and transport on semi-volatile material (eg ammonium nitrate)
- Chemical reactions on the filter
- balance drift, static electricity ….

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Constraints in EN 12341:1999

- standard conditions during weighing:

  20 ± 1 °C ; 50 ± 5 % RH
- filter material: quartz

  good for lack of reactivity; chemical analysis; cheaper than PTFE

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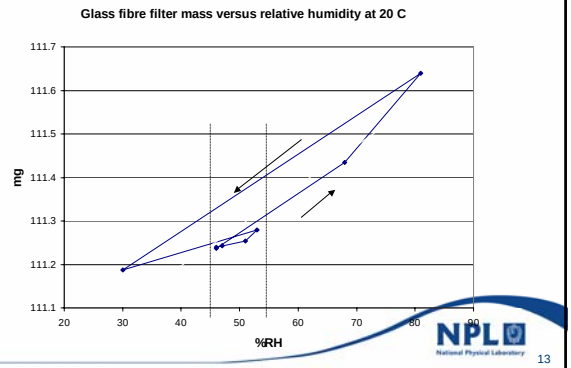
Humidity dependence of filters



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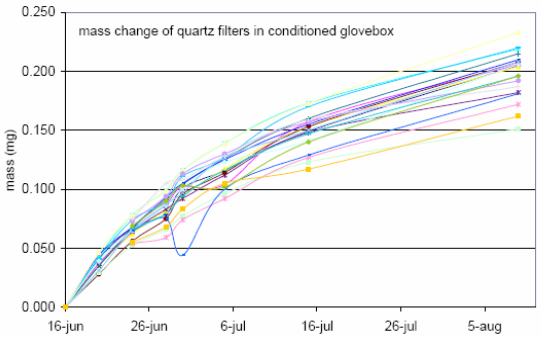
Recent VMM results (50% RH)



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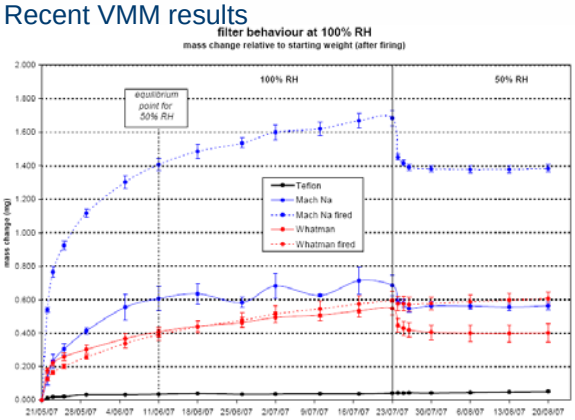
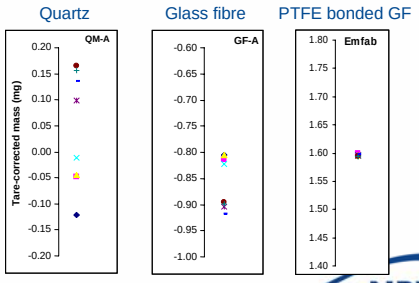
Recent VMM results



Filter material

Tare-corrected weighings at different T, RH



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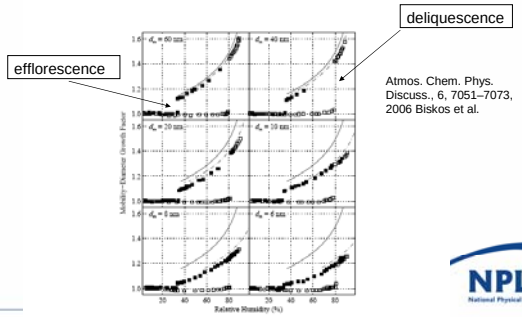
Water hysteresis effect on ammonium sulphate



Atmos. Chem. Phys. Discuss., 6, 7051–7073, 2006 Biskos et al.

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Water hysteresis effect

- There is a major difference in mass between PM on the upper “wet” branch of the growth curve and the lower “dry” branch (~30% of mass at 50%RH).
- The variation of PM mass as the humidity changes is much larger on the “wet” branch than on the “dry” branch
- Lower humidity during conditioning would help (US EPA requires 30-40 ± 5 % RH)

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Constraints in EN 14907:2005

- standard conditions during weighing remained the same:

  20 ± 1 °C ; 50 ± 5 % RH

- filter materials: quartz, glass fibre, PTFE and PTFE-coated glass fibre

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Constraints in EN 14907:2005

- sheath flow to avoid overheating during sampling
- requirements for temperature during storage and transport of samples
- criteria for repeatability of weighings

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Decisions in revision of EN 12341

filter materials:

quartz, good chemically, friable, humidity effect

glass fibre, less good chemically, humidity effect

PTFE, no humidity effect, pores can block

PTFE-coated glass fibre, no humidity effect, can be blocked by excessive water

NB “quartz” and “glass fibre” come in many forms

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Decisions in revision of EN 12341

Humidity during conditioning - to lower below 50%?

Pre-conditioning filters at high humidity?

Specifying filter materials / characteristics?

NB Regulatory consequences of change

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Also in CEN TC 264 WG 15

Convenor Ton van der Meulen (RIVM, NL)

Secretariat VDI-DIN

New work item: automated PM monitors

Likely to include:

(1) type approval, including laboratory tests and field tests, in line with the field tests required by the current Equivalence guidance;

(2) data treatment and validation, including low and negative values, outliers, and averaging

(3) Ongoing QA/QC, to include sample periods of parallel operation with the standard method.

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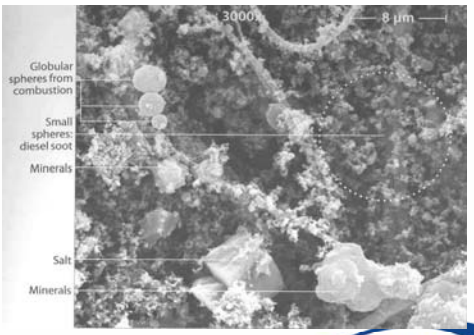
A wider view

Particles are a highly variable mixture of dust, coagulations of soot particles, secondary particles etc



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A wider view

Is total mass on a filter the best parameter?

Can measurement uncertainty for PM_{10} or $PM_{2.5}$ ever be much better than ±25% ?

Regulation and standardisation do not encourage change

Health studies are constrained by available measured parameters

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A wider view

PM_{10} or $PM_{2.5}$ should not be addressed to the exclusion of other airborne particle measurements, eg

- Composition: nitrate, sulphate, ammonium, Organic Carbon, Elemental Carbon, Na^+, K^+, Cl^-, Ca^{2+}, Mg^{2+}, metals etc
- "Core" particles (not removed by heating) + selected compounds
- Oxidising capacity
- Particle number concentration / size spectrum

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Closing remarks

Sorting out measurement methods for PM is an important task

Even more so for $PM_{2.5}$ than for PM_{10}

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Thank you
Děkuji.

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