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Real time measurement of combustion aerosol size distribution
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Acknowledgements:
- Mikko Moisio, TUT Aerosol Physics
- Technology Development Centre of Finland, SIHT12 Research Program
- Technical Research Centre (VTT) Aerosol Technology Group
- Imatran Voima Foundation
Continuous measurement of size distribution?

- Fine particles have more health related effects than their mass fraction would indicate.

- Generation, collection and deposition of fine particles are size dependent.

- Short time-scale emissions.

- Unstable situations.

- Research and development of processes, cleaning devices.
SIHTI2 - project

- Field Evaluation of new real-time instrument concept
- Evaluation and improving sampling system
- Size distribution measurements on several different power plant types
- Short time-scale emission measurement
- Long term emission monitoring evaluation
Electrical Low Pressure Impactor

- Combines electrical detection with aerodynamic size classification

![Diagram of Electrical Low Pressure Impactor]

- **Electrical detection**
  - Real time response (~1s)
  - Good sensitivity compared to gravimetry (0.004 μg/m³ at Dp=0.03 μm)

- **Aerodynamic classification**
  - Particle size distribution range 0.03 .... 10 μm
Calibration

- Example of TUT ELPI impactor calibration: Collection efficiency of submicron stages (Keskinen et al. (1997) JAS, to be published)
SIHT12: measurement sites

- Pulverized coal power plants
- Mixed fuel (oil, natural gas, and peat) burners
- Kraft recovery boiler
- Lignosulfonate drying plant
- Sludge waste (paper/bio), fluidized bed
- Bark burning, circulating fluidized bed
Sampling

- Dilution
  - Ejector operated dilution (ratio 1:1-100)
  - Diluters heated to stack temperature
- Isokinetic sampling
- Pre cyclone (D50%=3 μm)

D=diluter
H=heater
PA=pressurized air
C=cyclone
■ =insulation
Comparison Measurements

• **ELPI vs. DMA**
  - sludge waste fluidized bed (data from Latvai-Somppi et al., JAS 1997 (in press)).

![ELPI vs. SMPS Diagram]

• **ELPI vs. BLPI**
  - Pulverized coal

![Mass distribution, Coal (ELPI vs. BLPI) Diagram]
ESP rapping and soot blowing

ESP rapping emission

Peat, boiler soot blowing emission
Size distribution change in fluidized bed combustion

Lower figure shows the bed temperature and fly ash mass concentration (as measured by ELPI and TEOM) during sludge and bark co-firing in a BFB. Upper figures compare ELPI and SMPS number size distributions during the period shown in the lower figure. Note the change in number concentration in just five minutes.

Diesel emissions

Diesel test run (bef. CAT)

Averaged distribution (40 min.)

- ELPI
- BLPI

FAAR97/MM
Conclusions

- Representative dilution possible below 5...10 \(\mu m\), but sample conditioning critical

- SMPS needs semi-stable conditions

- LPI use requires extreme care below 100 nm

- ELPI
  - Rugged
  - LPI resolution
  - Overall correlation with TEOM, LPI, DMA good
  - Spurious mass at coarse particles, when mass distribution peaks at fine particles: correction algorithm or size restriction
  - Reading dependent on particle density
  - Time resolution useful in R&D work
  - Transient capability for vehicle emission measurement
Vehicle emission application

- Time resolution now 2-5 s
- Possibilities for full transient capability
- Coarse particle size limited to 0.5...2 microns
- Lowest particle size now 30 nm
- Reading depends on particle density