Harmonisation of Ultrafine Particle Measurements

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Overview

- Beyond particle mass
- Particle counting & sizing
- Legislative position
- State of harmonisation
- Conclusions

Beyond Particle Mass

Particle Size (microns)	Relative Mass
0.05	1
1	8 000
2.5	125 000
10	8 000 000

Mass concentration applies a size-cubed weighting to each particle measured

d^3

Ultrafine = <100 nm = <0.1 micron = Nanoparticle

Size Weighting

- Number d^0
- "Joint Length" d^1
- Surface Area d^2
- Volume/Mass d^3

What is the best weighting for my subject of interest?

- Chemical activity
- Health effects
- Environmental impact

Particle Counting

Rural ~ 10^3 cm^{-3} Urban ~ 10^4 cm^{-3} Kerbside ~ 10^5 cm^{-3}

Aerosol Electrometer (AE)

- <10 nm
- Only charged particles of one polarity
- Concentration >10^3 cm^{-3}
- Mainly lab reference instrument

~~**Optical Particle Counter (OPC)**~~

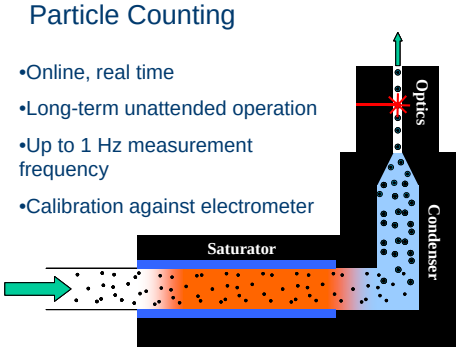
- >300 nm
- Also particle sizing

Condensation Particle Counter (CPC)

- <10 nm
- Concentration from Zero to >10^6 cm^{-3}
- No sizing information

Particle Counting

- Online, real time
- Long-term unattended operation
- Up to 1 Hz measurement frequency
- Calibration against electrometer



Particle Counting

Heterogeneous nucleation

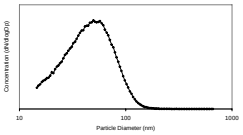
Transfer of working fluid to vapour phase

Particle Sizing

Size Selecting Device + **Particle Counter** = **Size Distribution**

- •Differential Mobility (<1000 nm)
- •Impaction (>100 nm)

- •CPC
- •Electrometer



Typical Modes in Ambient Air

- •Nucleation ~50 nm **OR** Nucleation <10 nm & Aitken 10-50 nm
- •Accumulation ~50-1000 nm
- •Coarse >1000 nm

(AQEG (2005) *Particulate Matter in the UK*. Defra, London.)

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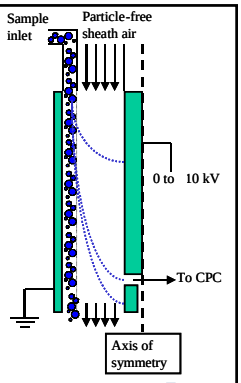
Particle Sizing

Differential Mobility Analyser (DMA)

- •Particles carry small & finite number of charges
- •Electric field applied perpendicular to laminar flow field
- •Particles cut across flow streamlines at velocity determined by the ratio of aerodynamic drag to electrical force
- •Narrow sampling apertures allow selection of a single mobility



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Particle Sizing

- Scanning/Stepping Mobility Particle Sizer/Spectrometer (SMPS)
- Online, real time
- Long-term unattended operation
- Measurements up once every minute
- Calibration for size against traceable Polystyrene Latex (PSL) nanospheres

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Legislation

- Air Quality
  - No regulatory requirement yet
- Vehicle Emissions
  - UNECE Regulation 83 for road vehicles
  - Aviation emissions, overseen by EASA & SAE-E31
- Toxicology (inhalation)
  - No nanoparticle-specific requirements
  - Defra voluntary reporting scheme

Similar measurements required for many different applications

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State of Harmonisation- Overview

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ISO Standards

- ISO 15900:2009
  - Determination of particle size distribution -- Differential electrical mobility analysis for aerosol particles
- ISO 27891 (in progress)
  - Aerosol particle number concentration -- Calibration of condensation particle number counters
- Both are general in scope to ensure relevance to many applications

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NMI activities

- EURAMET 1027
  - Comparison of combustion particle number concentration and size
  - Experiments held at METAS in November 2008
  - Participants: METAS, NPL, AIST, UBA, DFM, FORCE technology
  - Report available from www.euramet.org
- CCQM Key Comparison
  - Agreement in principle, with measurements due in 2010/2011

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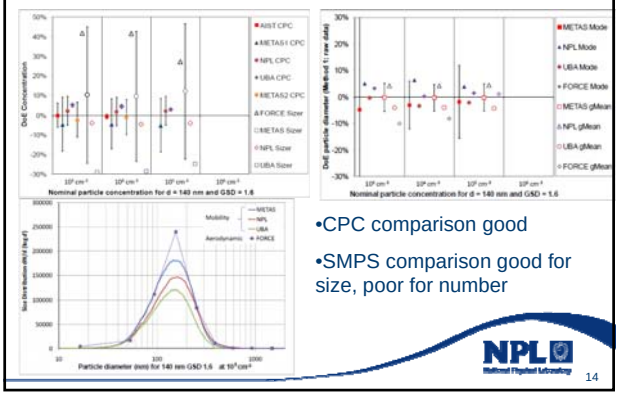
EURAMET 1027- Results



•CPC comparison good

•SMPS comparison good for size, poor for number

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Air Quality

- CEN/TC 264
  - Air quality -- Determination of the particle number concentration of atmospheric aerosol
- European Supersites for Atmospheric Aerosol Research (EUSAAR)
  - Standardised measurement protocols, intercomparisons and quality assurance
  - UK Particle Network upgraded to align with EUSAAR specifications

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Vehicle Emissions

- Shift from particle mass to number on transition from EURO4 to EURO5
- Measurement/calibration procedures developed by the Particle Measurement Programme (PMP)
- Many lessons learnt relevant to other applications

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Toxicology

- National Nano-toxicology Research Centre
  - Collaboration between academic and government organisations
- £1M investment so far by the Health Protection Agency
- Laboratory facility near completion
- First symposium held in November 2009

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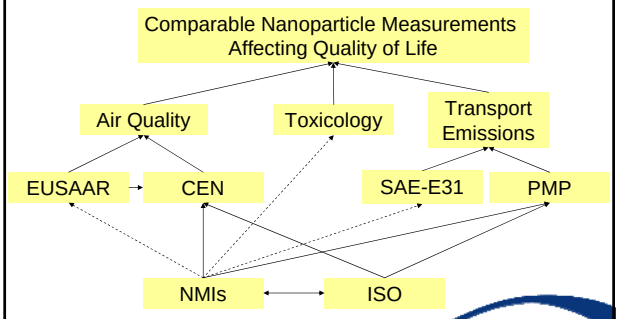
How it all fits together…



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Conclusions

- Size-weighting of traditional measurements has required the development of Ultrafine particle measurements.
- Many applications require similar measurements but with different constraints.
- The metrology and standards supporting particle counting/sizing is developing on many fronts to support anticipated future scientific and legislative needs.

Thank you

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Upcoming Meetings

- RSC PCIG- Characterisation of sub-micron and nano sized materials
  - 17th March 2010, Royal Pharmaceutical Society
- Aerosol Society- Annual Aerosol Science Conference
  - 8th & 9th April 2010, Southampton
- Metrology of Airborne Nanoparticles, Standardisation and Applications (MANSA)
  - 8th - 10th June 2010, NPL. www.npl.co.uk/events/mansa
- 14th ETH-Conference on Combustion Generated Nanoparticles
  - 2nd - 4th Aug 2010, Zurich
- International Aerosol Conference
  - 29th Aug - 3rd Sep 2010, Helsinki
- European Aerosol Conference
  - 2011, Manchester