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Detection of nanoparticles in workplace using inexpensive instrument based on ionization-type smoke detector

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Warning: Many devices you commonly use may produce nanoaerosols which may seriously harm you when inhaled.

Background:

- Nanoparticles pose health risks.
- Typically they are not detectable by human senses.
- There are good instruments, but they are expensive, cannot be everywhere, many would be needed.
- Smoke/fire detection technology explored: Optical sensors insensitive to nanoparticles. Ionization chamber response similar to diffusion charging instruments.

Goal: To characterize the response of an ionization smoke detector chamber to various concentrations and types of nanoparticles.

Experimental:

- Ionization chambers from commercial smoke detectors equipped with more stable electronics, a sampling system, a datalogger and a user interface.
- Laboratory and field tests conducted with various aerosols and reference instruments (see graphs).
- Conversion of signal to particle number assuming 80 nm mean diameter, 1.8 geom. standard deviation

Key findings:

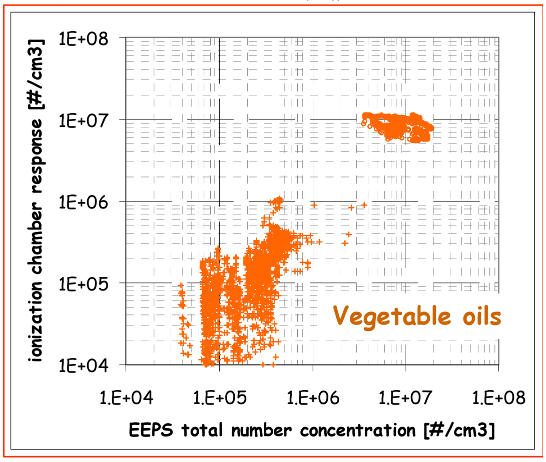
- Response proportional to total length (or in between total length and surface area); for small particles, this is closer to Lung Deposited Surface Area than number or mass measurement.
- Obviously, when recalculated to number concentrations, response is different for different sizes.
- **In the field tests, 2-3 x 10^5 particles/cm^3 detected for various size distributions, incl. nano.**
- **Laboratory tests show sensitivity to 40 nm particles (smallest diameter tested)** at < 10^5 #/cm^3.
- **Response confirmed for many types of material** (diesel and gasoline exhaust reported previously).

Discussion & open questions:

- **In most cases, limit / threshold should be well above "normal" "background" concentrations, otherwise presence of vehicles, motorized machinery, etc., will trigger the response.**
- **Some characterization of aerosol and assessment of "hazardous" concentration advised for individual cases; in some cases, the instrument described here might not be sufficient.**

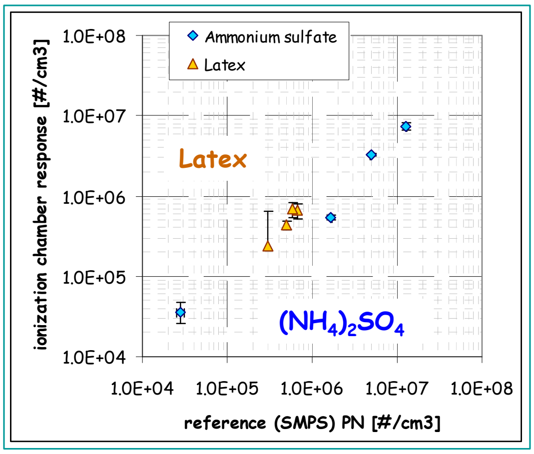
Vegetable oils

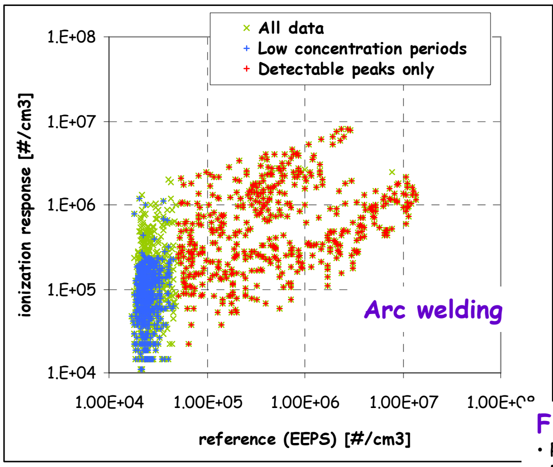
- Incomplete combustion in diesel engine (diluted exhaust)
- Reference: Engine Exhaust Particle Sizer
- Inherent noise about 2 x 10^5 #/cm^3

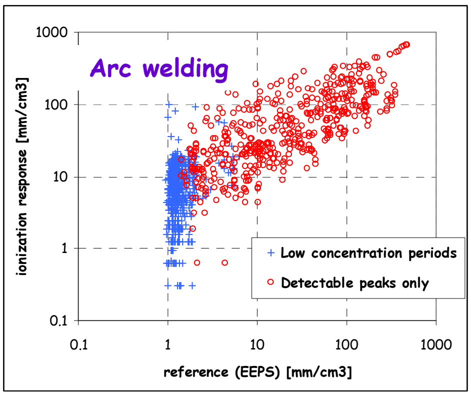


Ammonium nitrate and latex

- Laboratory tests using generators, steady-state
- Reference: Scanning Mobility Particle Sizer
- Detection limit 10^4-10^5 #/cm^3

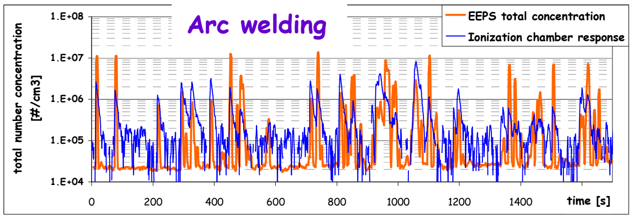


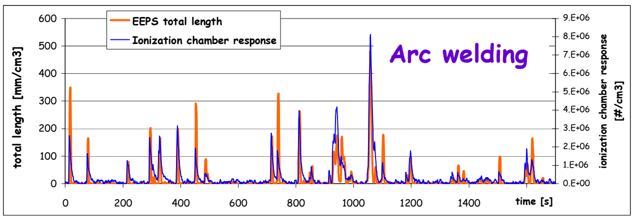


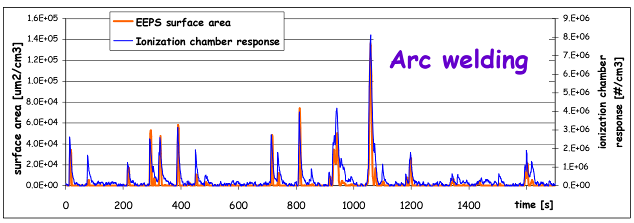


Field test: Arc welding aerosol

- Reference: Engine Exhaust Particle Sizer
- Response proportional to in between total length and total surface area
- Inherent noise about 2 x 10^5 #/cm^3 or 2000 um^2/cm^3







Thermodenuded soot

- Laboratory tests within European Metrology Research Program
- Reference: Scanning Mobility Particle Sizer
- Response proportional to total length
- Noise & detection limit 10^4-10^5 #/cm^3 (EMRP data, not shown here)

„The measurement principles electrical charging and sensing as well as the ionization chamber can be considered as suitable for measuring of sub 100 nm particles from modern diesel vehicle exhaust."

Report D-212, WP2: Evaluation of measuring methods for particle emission from modern diesel vehicles in periodic emission control, ENV02 PartEmission, European Metrology Research Program (EMRP), https://www.ptb.de/emrp/partemission-publications.html