FILTECH 2019
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Koelnmesse, 24th October 2019
Session G16 - Particles for Filter Testing, 13:00-14:15

"New synthetic nano-aerosol for accelerated realistic ageing of air filters"

J. Marval[1], L. Medina[1], E. Norata[1], P. Tronville[1]
[1]Politecnico di Torino, Turin, Italy

POLITECNICO DI TORINO
Department of Energy "Galileo Ferraris"

AEROSOL TECHNOLOGY LAB

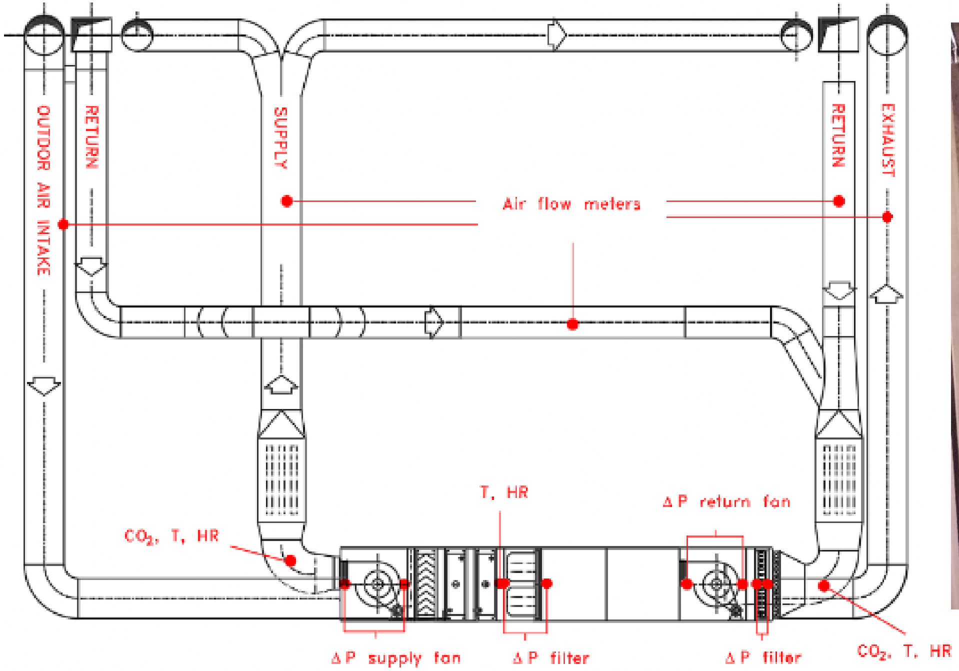
Parameters characterizing HVAC air filters

- Efficiency: ability to capture aerosol particles; the reason why air filters are installed in an HVAC system
- Airflow resistance: the price to pay for cleaning the air; linked to the energy use (not obviously) and to the airflow rate in the system
- Service life: the expected amount of time before the filter needs to be replaced; it depends on how fast its airflow resistance increases while capturing the aerosol particles

We studied how air filters are aged naturally in an HVAC system and compared the data obtained with a standardized test

Comparison between in-situ and artificial filter ageing

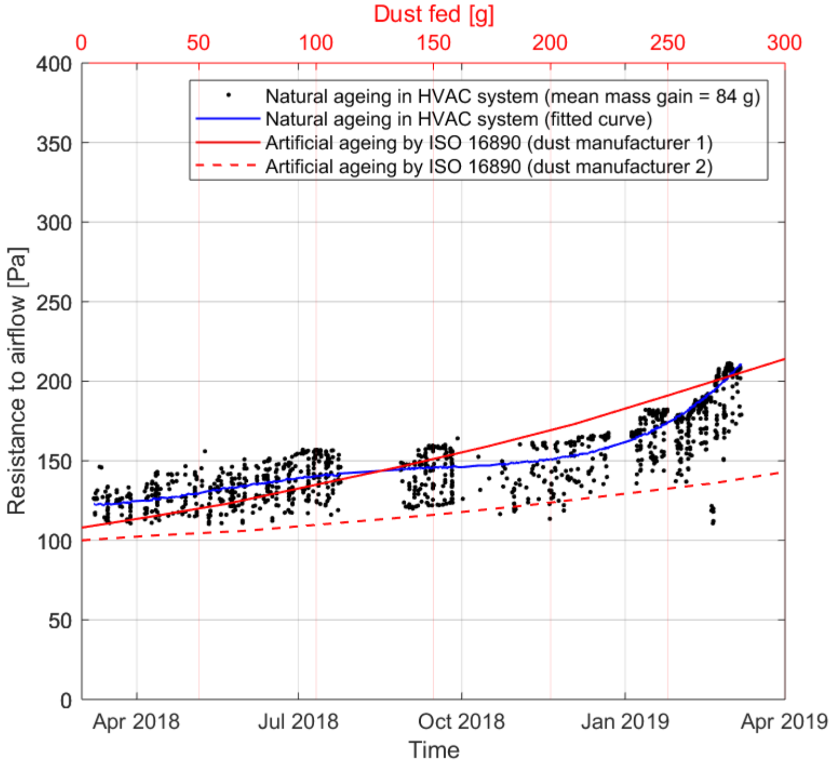
HVAC system serving a large classroom at Politecnico di Torino



Comparison between in-situ and artificial filter ageing

The in-situ aged filter shows different pressure drop trend throughout its service life, compared to the ones aged in the laboratory test

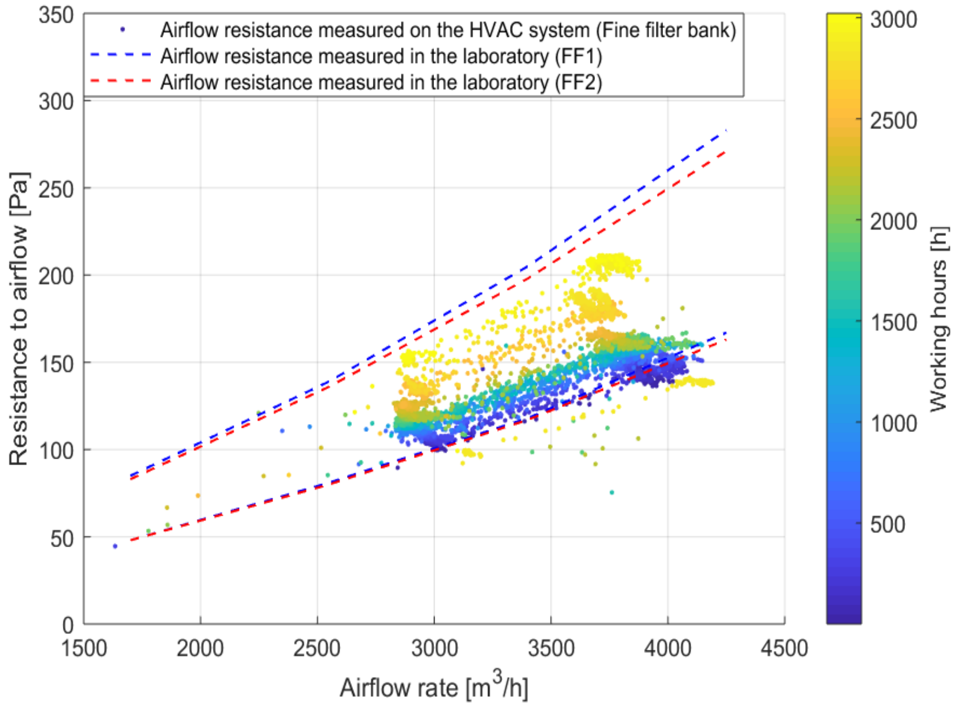
- ➢ Surface filtration vs. deep filtration



Comparison between in-situ and artificial filter ageing

- Dashed lines represent airflow resistance data in lab, before and after the natural ageing of HVAC filters

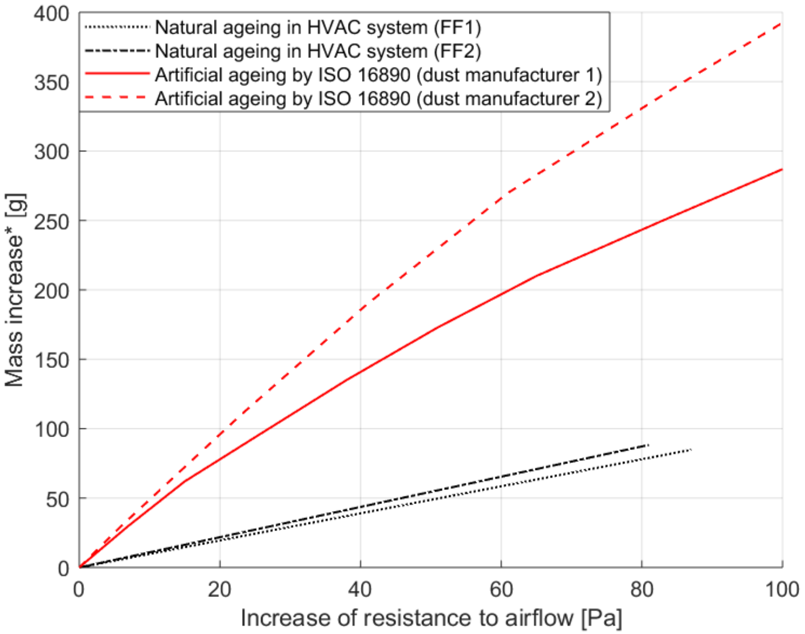
- The points cloud corresponds to in-situ measurements



Comparison between in-situ and artificial filter ageing

- Filters used in a real HVAC system reach the same airflow resistance of the artificially-aged filters with much lower mass of captured particles

- Big difference between the two aerosol particle size distributions and their effect on the loading kinetics of the filtering media



Urban atmospheric aerosols

The mass particle size distribution of this type of aerosols is characterized by three distinct modes:

- Nuclei (negligible in terms of mass)
- Accumulation
- Coarse

The volume, surface and number particle size distributions are very different

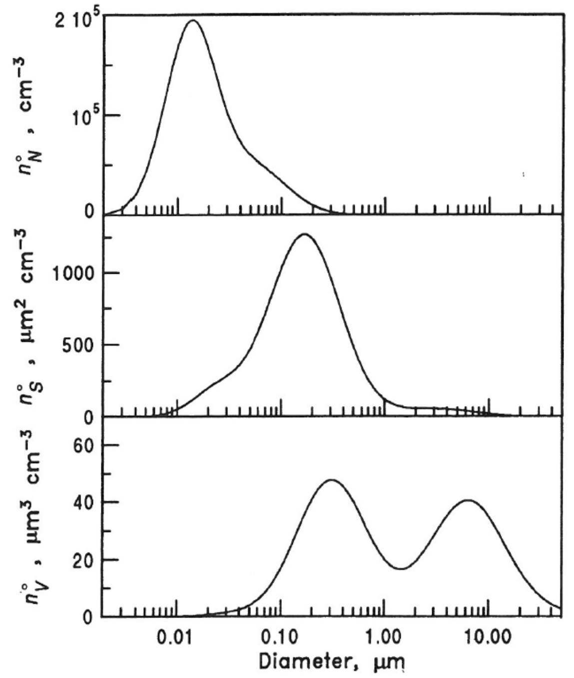
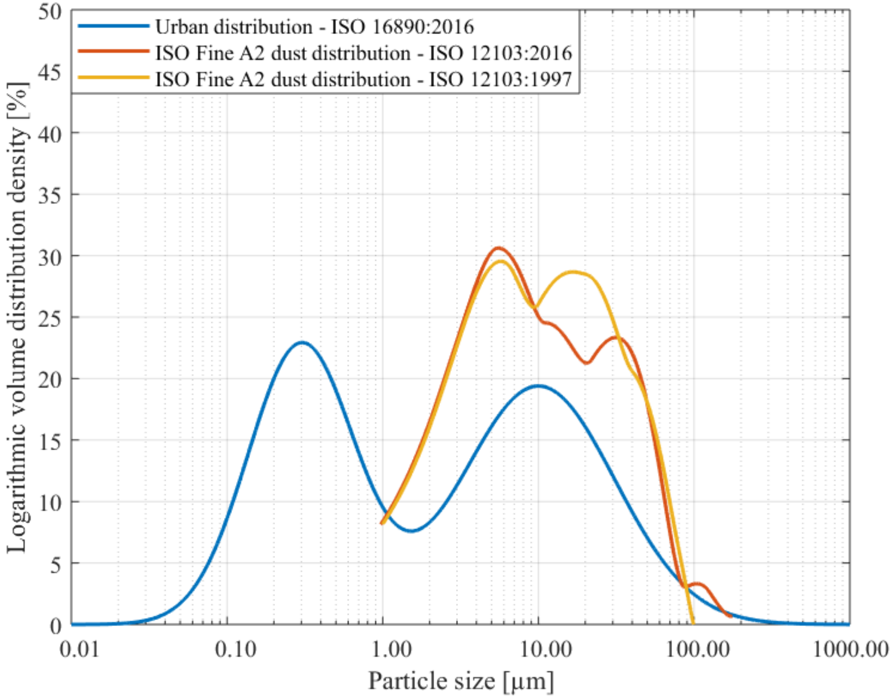


FIGURE 8.11 Typical urban aerosol number, surface, and volume distributions.

Seinfeld J. H., Pandis S. N., 2012.

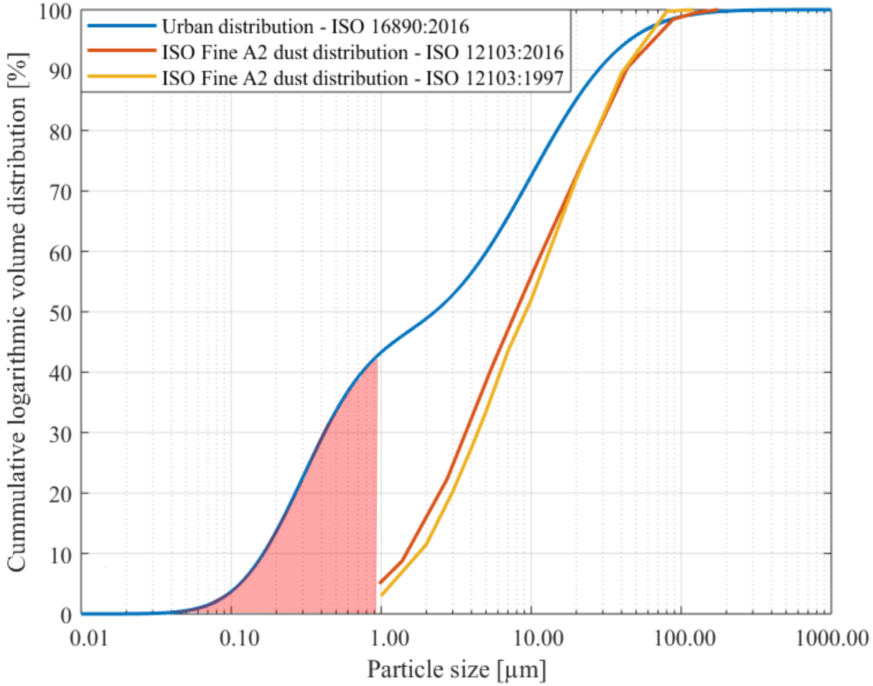
Urban atmospheric aerosols vs synthetic dusts

The volume (i.e. the mass) distributions as a function of particles size of currently standardized test dusts (ISO Fine dust used by ISO 16890) are very different from typical urban atmospheric aerosols



Urban atmospheric aerosols vs synthetic dusts

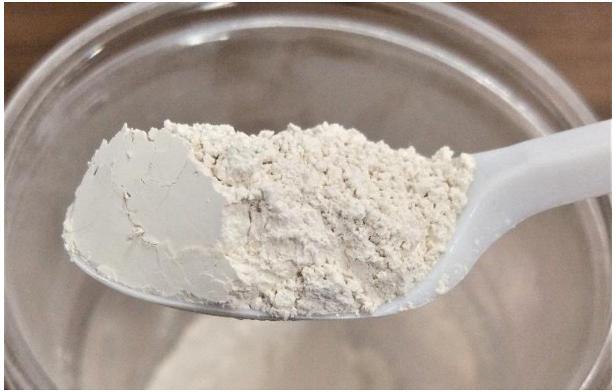
About 45% of the mass of the particles in the urban aerosol distribution proposed by ISO 16890 are smaller than the smallest particles in the ISO fine dust



Natural ageing of HVAC filters

Artificial ageing with ISO Fine dust

ISO Fine dust prescribed by ISO 16890 to assess the test dust capacity of HVAC air filters



Artificially-aged fine filter

Motivation for a new ultrafine synthetic aerosol

- The main goal of current standardized test methods is to compare one HVAC air filter to another, not to predict their in service performance
- ISO 16890:2016 made a big step ahead by providing *e*PMx values for a typical application (100% outdoor air in urban and rural areas)
- The different behavior of air filters during laboratory tests and in service is linked to their ageing process (artificial or natural), i.e. to the different characteristics of the challenging aerosols in these two conditions
- Current procedures are not able to predict quantitatively the in-situ air filters performance, nor their energy impact (i.e. energy rating in lab is not able to predict energy use in practice)
- Need to generate in laboratory a synthetic aerosol simulating much better the atmospheric one, i.e. to fill in the gap preventing a more realistic simulation in the laboratory (ASHRAE RP-1734)

Methods to generate highly concentrated nanoaersols

Requirements

- Match sub-micrometer urban aerosols mass PSD with possibility to adapt the generated PSD
- High mass output rate for PM ≤ 100 nm (above 10 g/h)
- Minimize the aggregation or growth of the smaller particles, to respect the target PSD along the test duct until reaching the test section
- Cost and ease of integration with existing test rigs (feasibility)

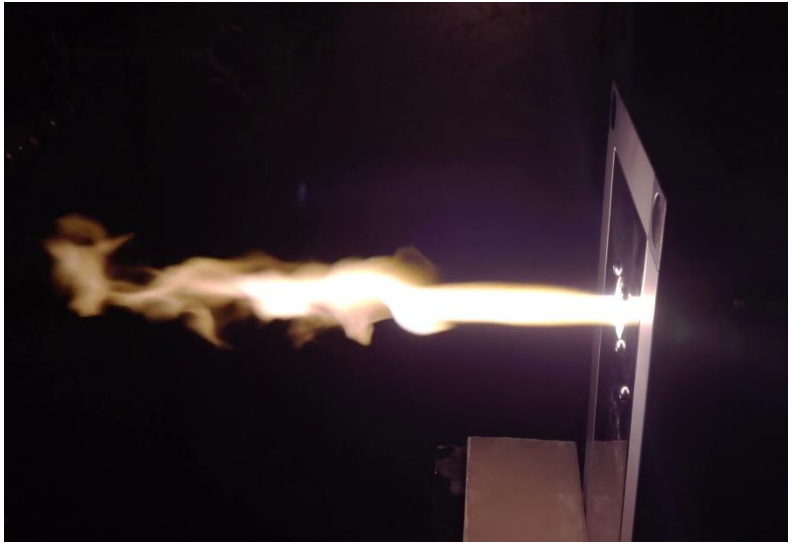
Existing technologies: atomization, nano-powder dispersion, tube furnace evaporation/condensation, glowing wire generation, spark discharge.

Nanoaerosol thermal generator

This device can be used to generate large amounts of ultrafine particles (nanoaerosol) to test HEPA filters in situ

Parameters

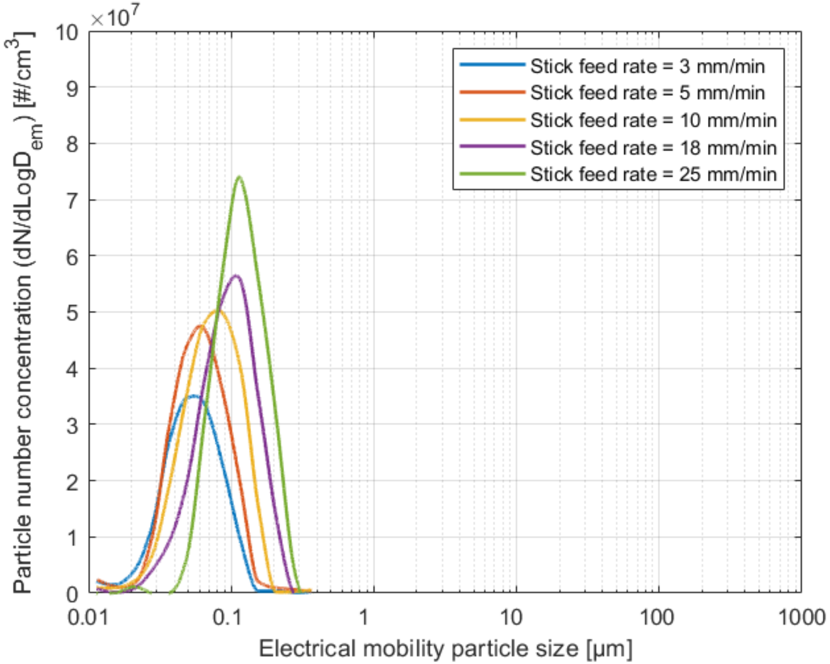
- Salt stick feed rate into the oxy-propane flame (1 to 25 mm/min)
- Diameter of the salt stick (10 or 12 mm)



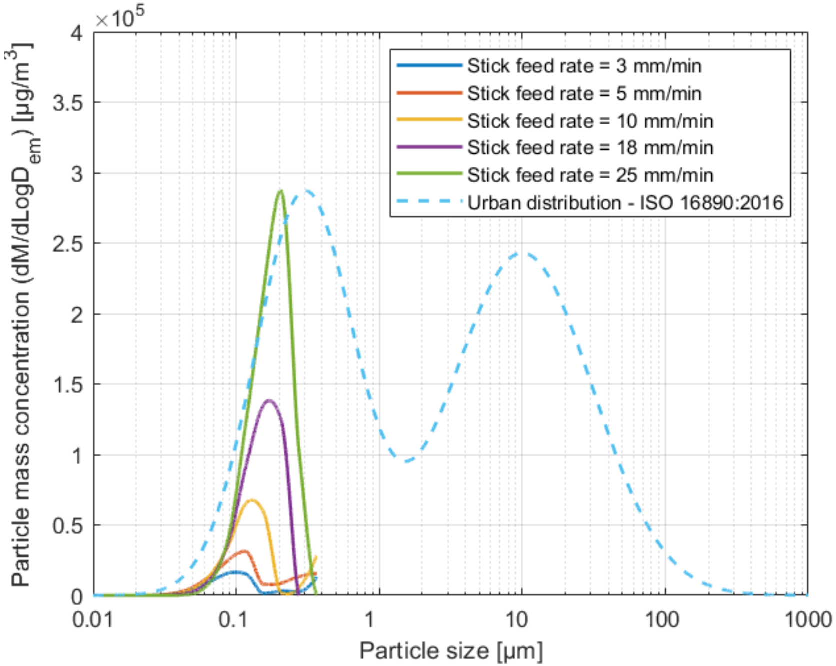
Preliminary test conditions

- Standardized ISO 16890 test duct operated at 3400 m^3/h
- The temperature between 20.6 and 34.6 °C
- Relative humidity between 33 and 55%
- The aerosol thermal generator injected the particles from the same point where the dust feeder is usually placed to age air filters with the standardized synthetic dusts
- The particle size distributions were measured with a TSI 3910 nanoparticle sizer and a PMS LAS-X II

Mass distribution of ultrafine synthetic aerosol



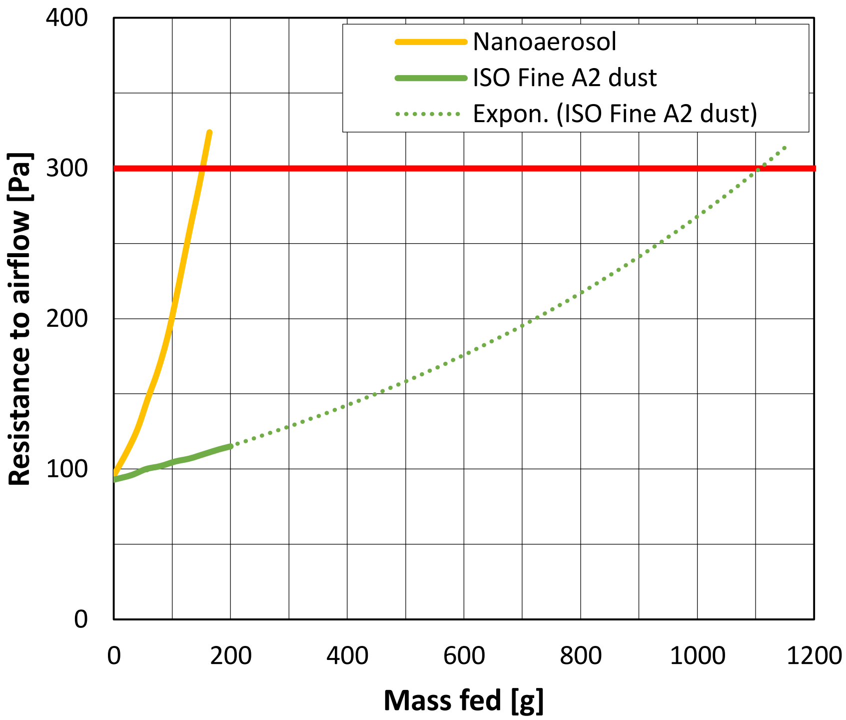
The concentration of the generated nanoaerosol is increasingly higher for faster salt stick feed rates



The synthetic nanoaerosol can represent the accumulation mode of a typical urban aerosol

Clogging tests – ISO Fine dust vs nanoaerosol

- Around 1100 g of ISO Fine dust needed to reach 300 Pa
- Only 150 g of KCl nanoaerosol were necessary to reach the same final pressure drop (10 mm-diameter salt stick at 10 mm/min)
- The trend of the clogging curves is quite different and the mass increase of the tested filter much closer to the natural ageing process



Conclusions

- The ageing behavior of air filters in HVAC systems is dramatically different from what current laboratory simulations provide
- To bring the laboratory simulations closer to reality, it is essential to simulate the filter ageing with much smaller particles than those present in current normalized synthetic dusts
- We adopted a controlled combustion process to generate large amounts of ultrafine particles
- In a few hours the nanoaerosol thermal generator could completely clog an air filter with a test dust capacity of around 1100 g
- New approach looks promising and it will be developed further

Thank you for your attention!