VERT Forum – 19th March 2026 at METAS Bern

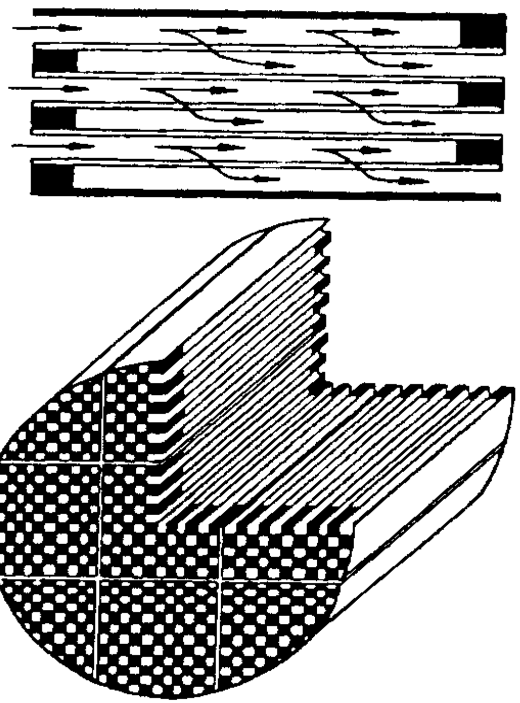
Ceramic Multicellular Filters CMF versus Traditional Fibre Filters TFF for Indoor Air Quality IAQ

A.Mayer / VERT

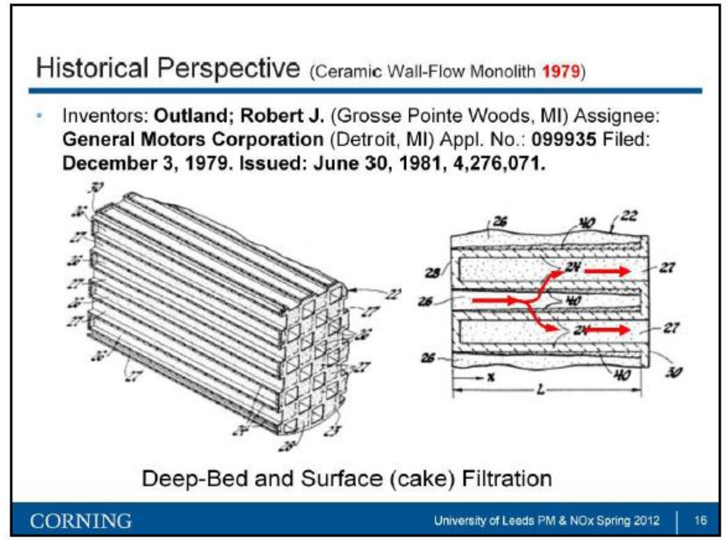
CMF- Filter for Diesel-Exhaust since 1982

now over 300 Mio successful on the road

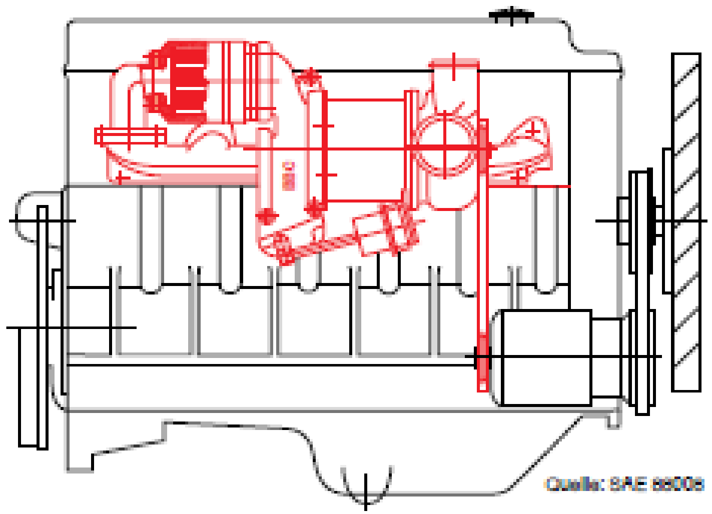
1982
Corning



1979
GM



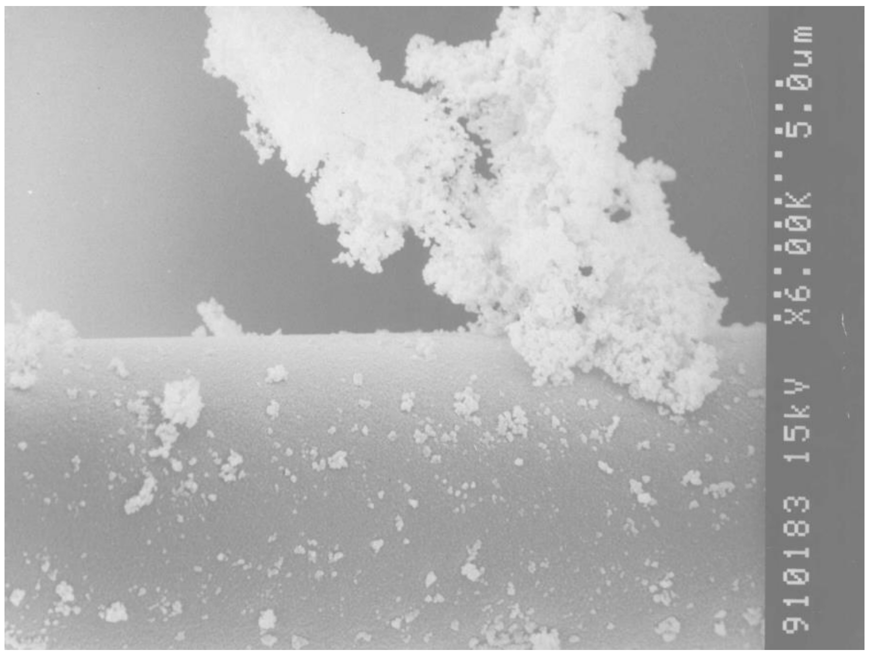
1985
BBC-DB
SAE -A.Mayer

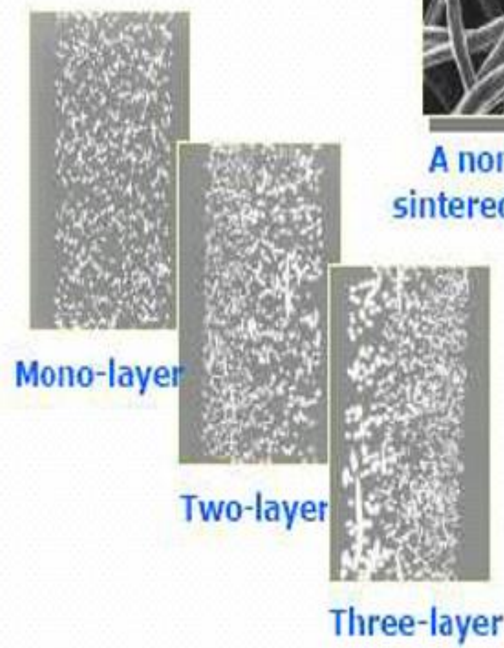


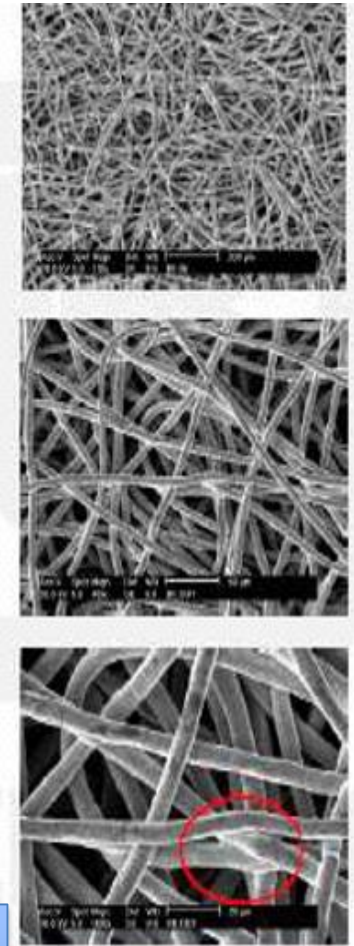
Materials: Cordierit, Silicon Carbide & other Ceramics
Standards: EU-Vehicle Emissions Standards EU5/V
SN 277206 in Switzerland

Fibre Filters *(no sieves)*

based on natural or technical microfibre papers (lat. filtrum) historical origin products







Materials: Cotton, Wool, Cellulose, Glas, Synthetic Plastics like Polyamid, less often Ceramics, Metals

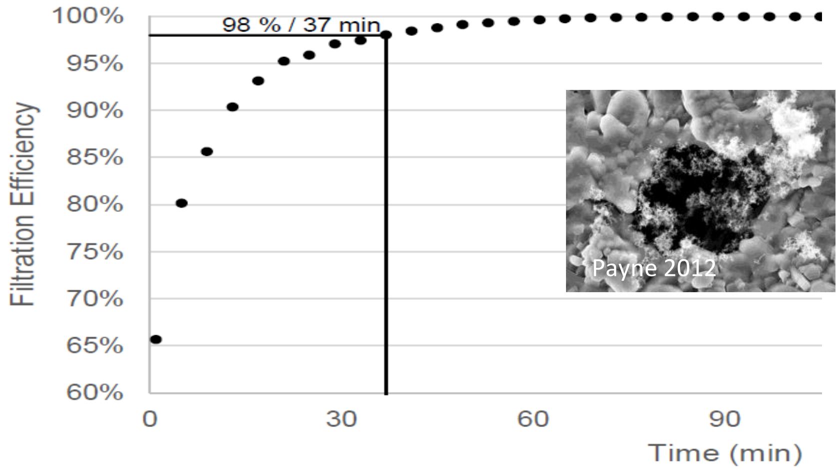
Standards: ISO, EN, DIN and ASHRAE
Grob- und Feinstaub EN779
Schwebestoff EN 1822 E10- U17

Filtration Principles

CMF is a surface filter

→ Deposited particles form a cake (VERT-2000)

→ Can be perfectly cleaned by backflow

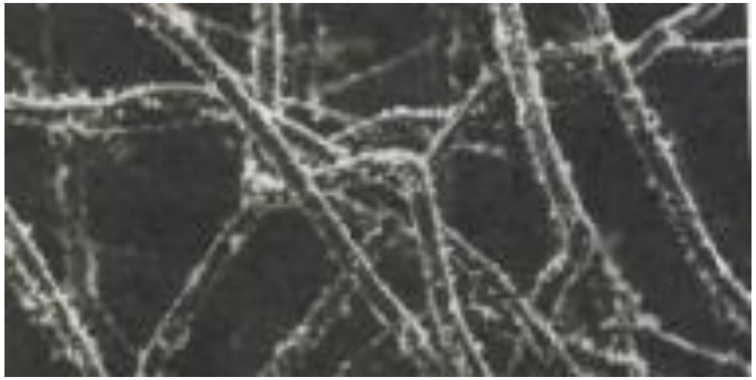


TFF is a deep bed filter

→ Deposited particles remain isolated (Jodeit 1985)

→ very difficult to clean

→ must be exchanged when loaded → cost, life



Which one is better suited to clean indoor environments from nanoparticles from outside and inside sources ?

CMF is a one-Purpose Development

has been developed with the unique target to be installed in combustion engines exhaust sytems (Diesel and Petrol) in order to collect solid soot particles and regenerate the filtrate without any secondary emissions. From many different concepts the extruded multicellular wall flow filter has prevailed because of smallest size, robustness, nanofiltraton and introduced in the automotive market – so far never in other application.

TFF covers different Forms and Applications

Historically TFF have solved all filtration target in the private and industrial world but for the exhaust gas filtration, although I tried myself, it could not compete with CMF because of the challenges for nanofiltraton, minimum installation size, robustness, cleanability and transient temperature.

Which one is better suited for indoor environments to clean nanoparticles from outside and inside sources ?

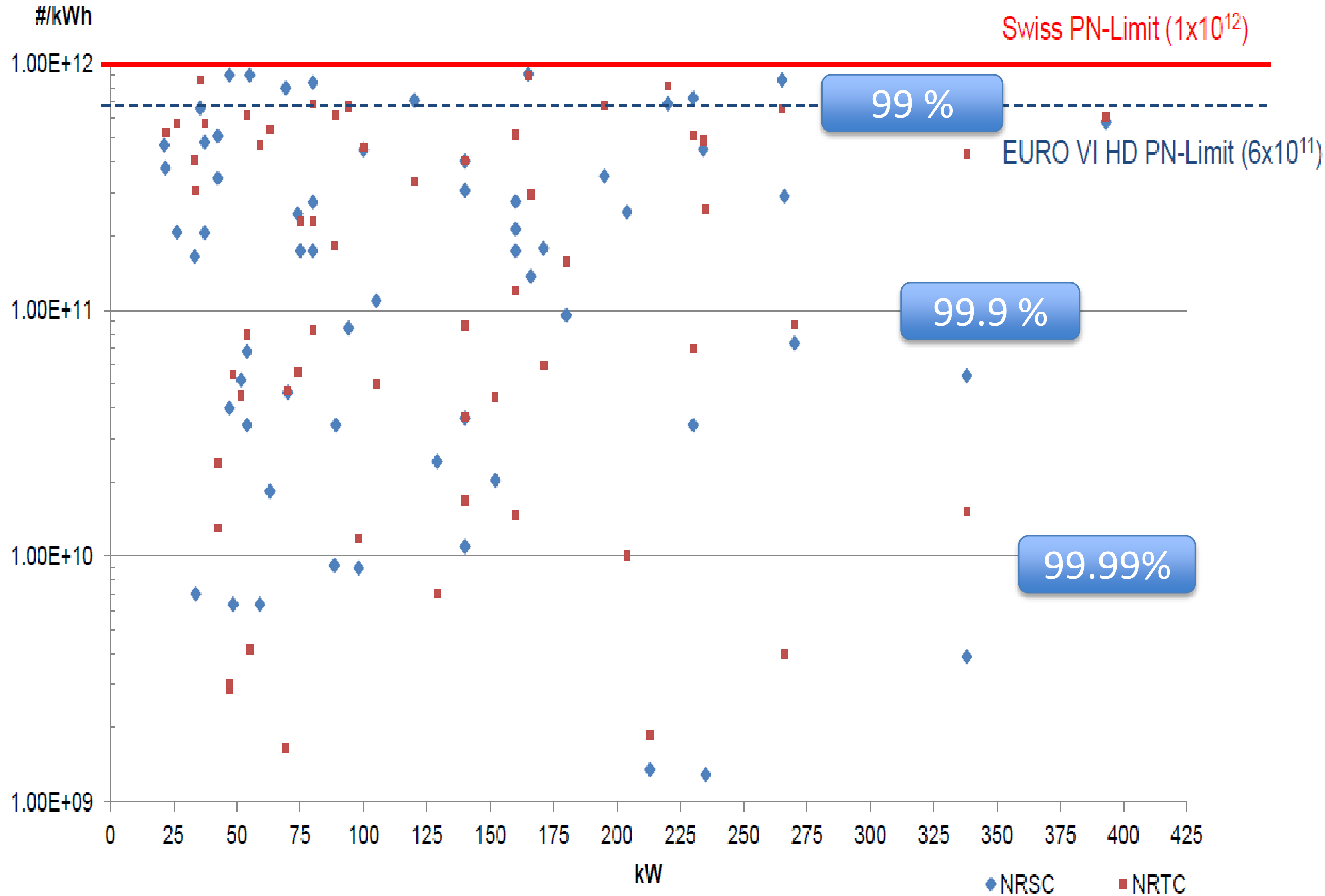
EU adopts CMF in 2006

EU Co-Decision (Art.12, Rec.15)

- In order to achieve these environmental objectives it is appropriate to indicate that **particle number limits** are likely to reflect the highest level of performance with **particle filters** using best available technology

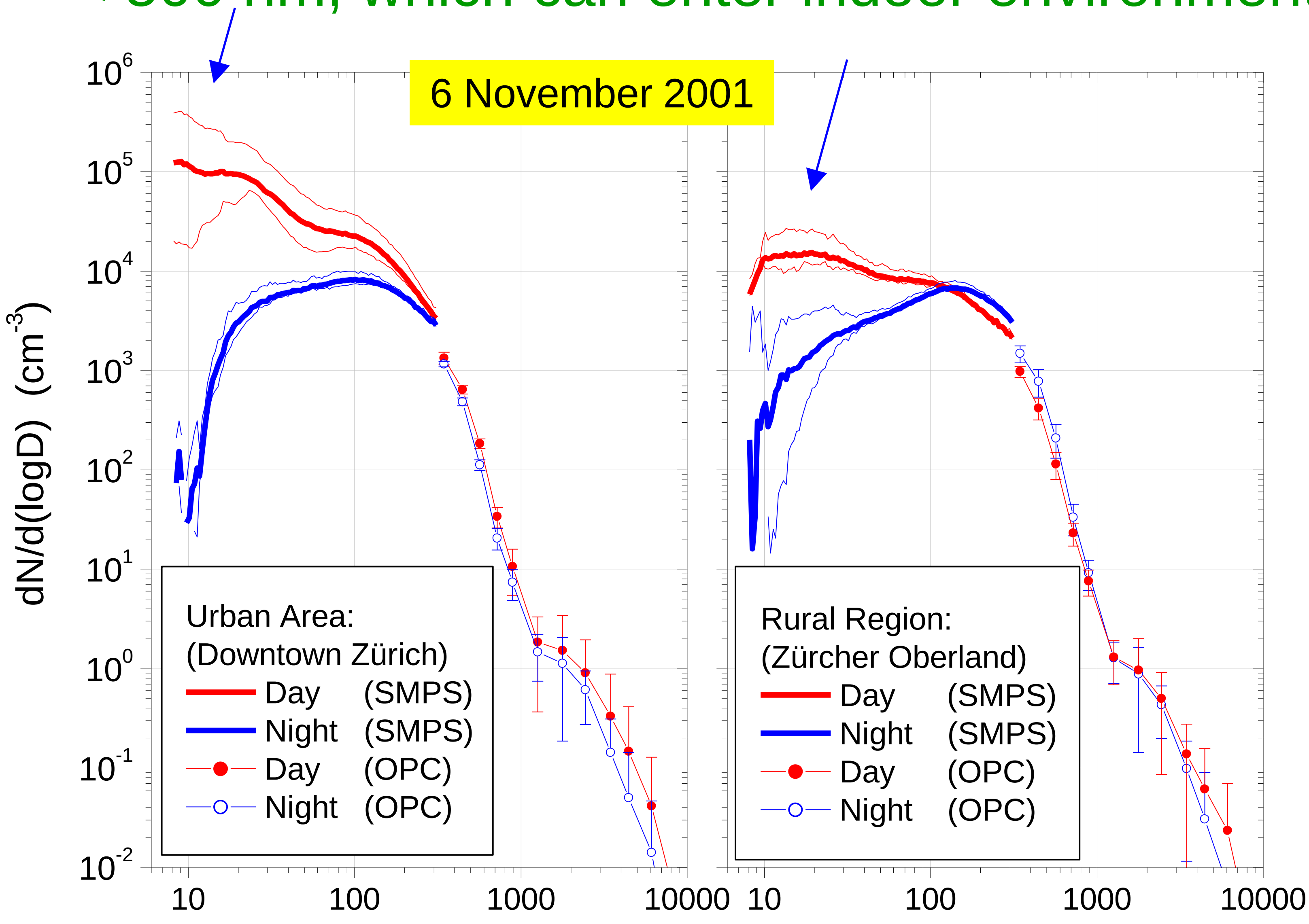
Quality of VERT certified Diesel Particle Filters

source Swiss FOEN



Target 1

Eliminate all traffic related (carcinogenic) solid particles < 500 nm, which can enter indoor environment

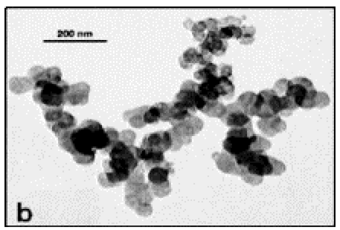


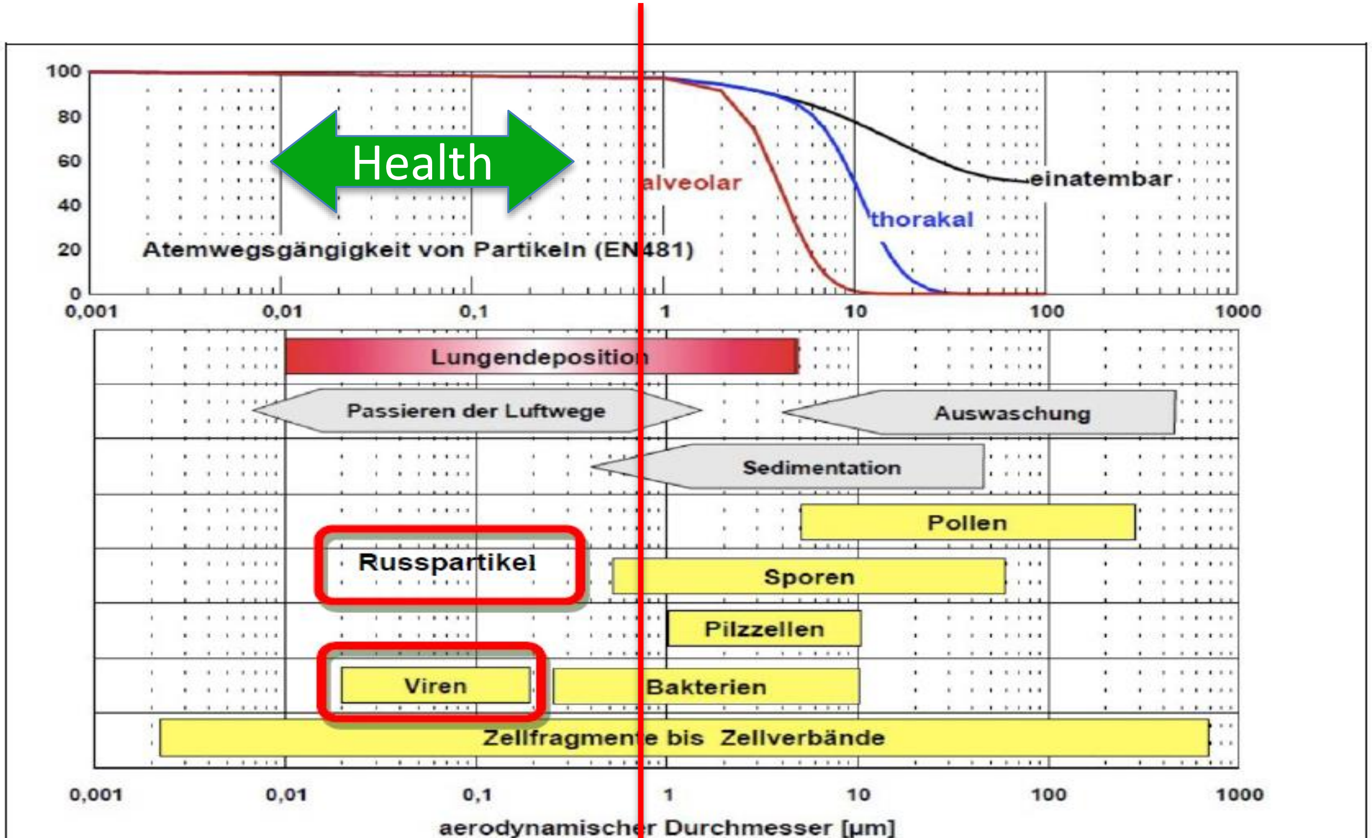
Bukowiecki et al., Atmospheric Environment, 2002

Target 2

Eliminate all Nano-Aerosols from Indoor Origins

which are affecting Health

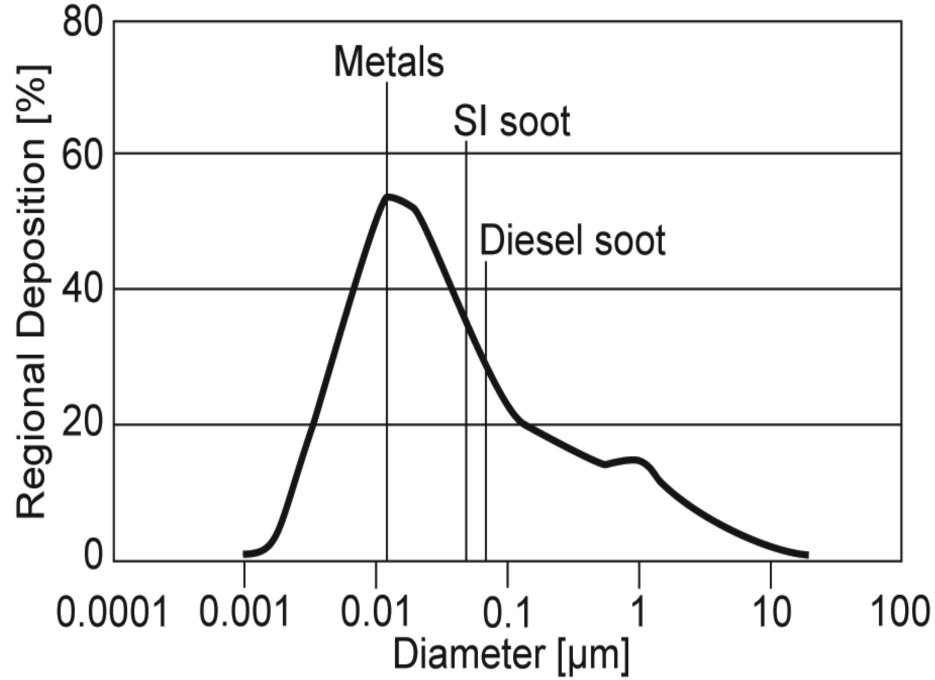


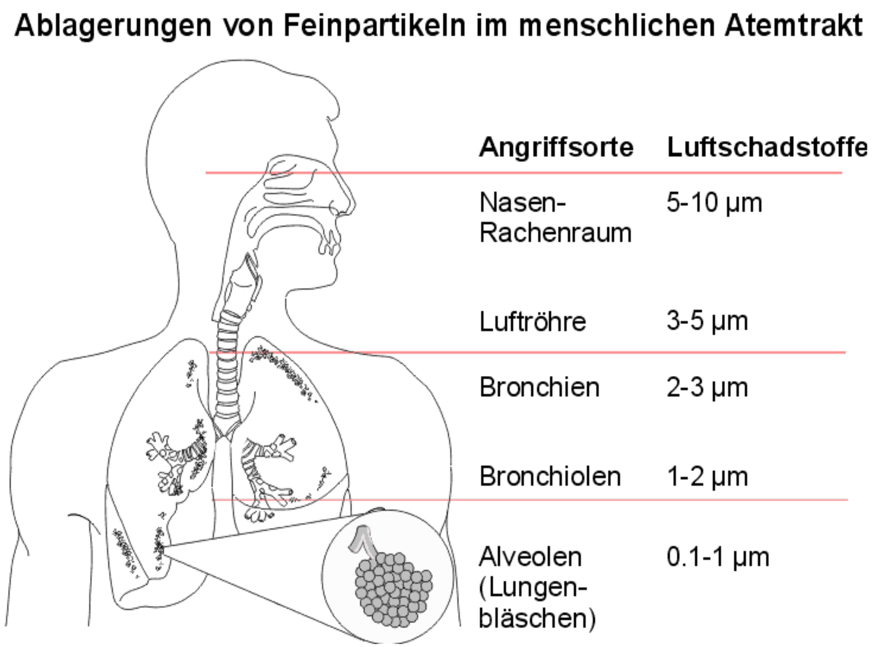


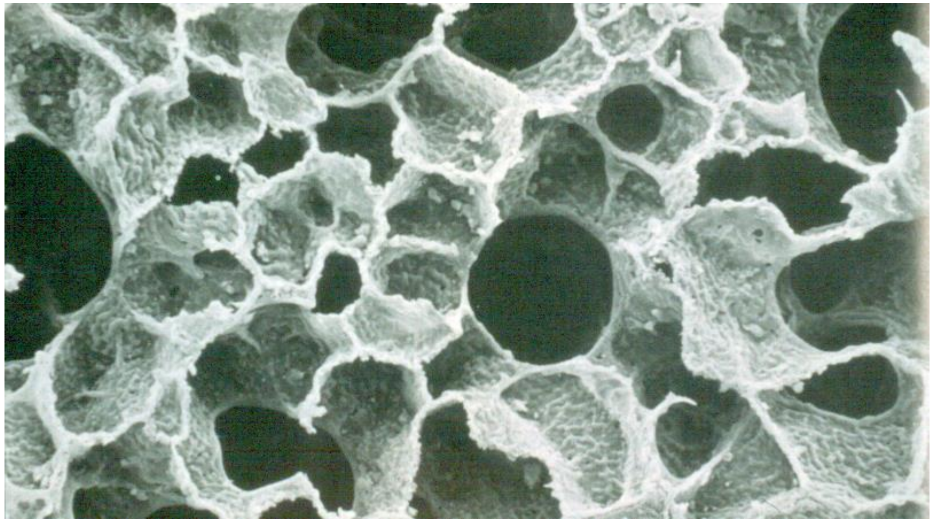
Grössenverteilung von pathogenen Keimen (Hoppenheidt 2002)
Im Vergleich zu Dieselrusspartikeln

„The smaller the more important“ Blaise Pascal

Importance to Particle Size for Health Risk Considerations



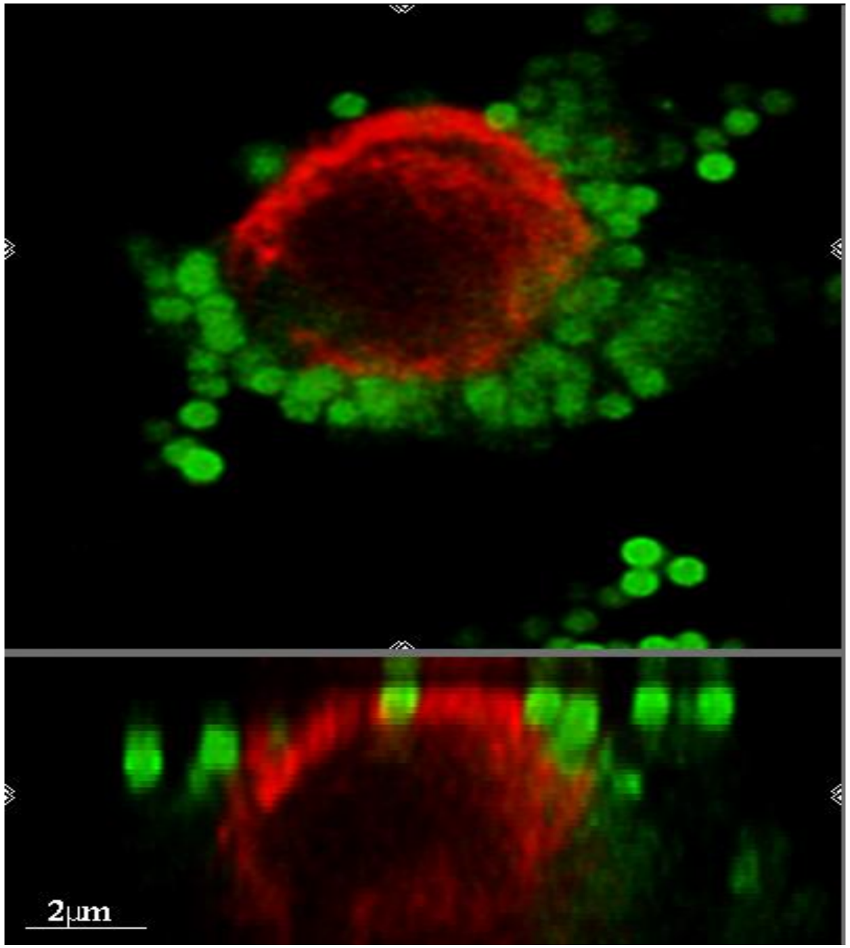




Ultrathin alveolar tissue permits penetration of gases and UFP into blood vessels

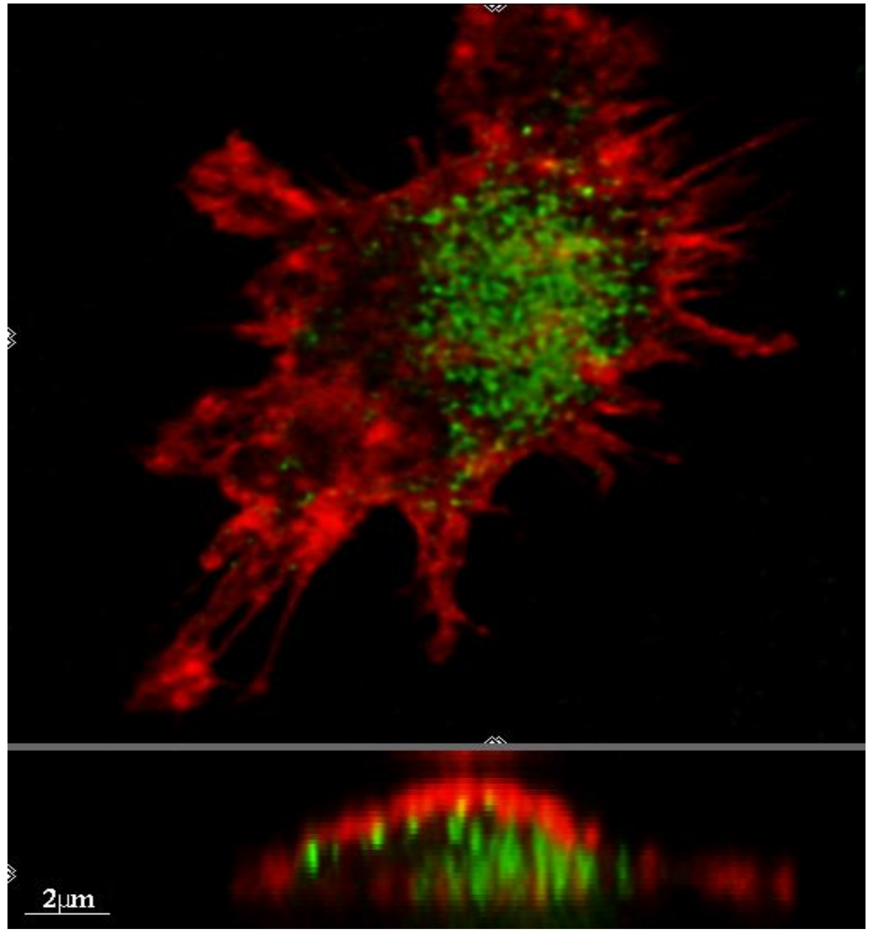
Particle Size Penetrating Membranes

1000 nm
Polystyrene Particles



Laser Scanning Microscopy

78 nm
Polystyrene Particles



Prof.B. Rothen-Rutishauser, Uni Fribourg
Prof.Peter Gehr, Uni Bern

Target 3: reach WHO guidelines

WHO Global Air Quality Guidelines 9/2021

after 25 years of PN Standard for Engines

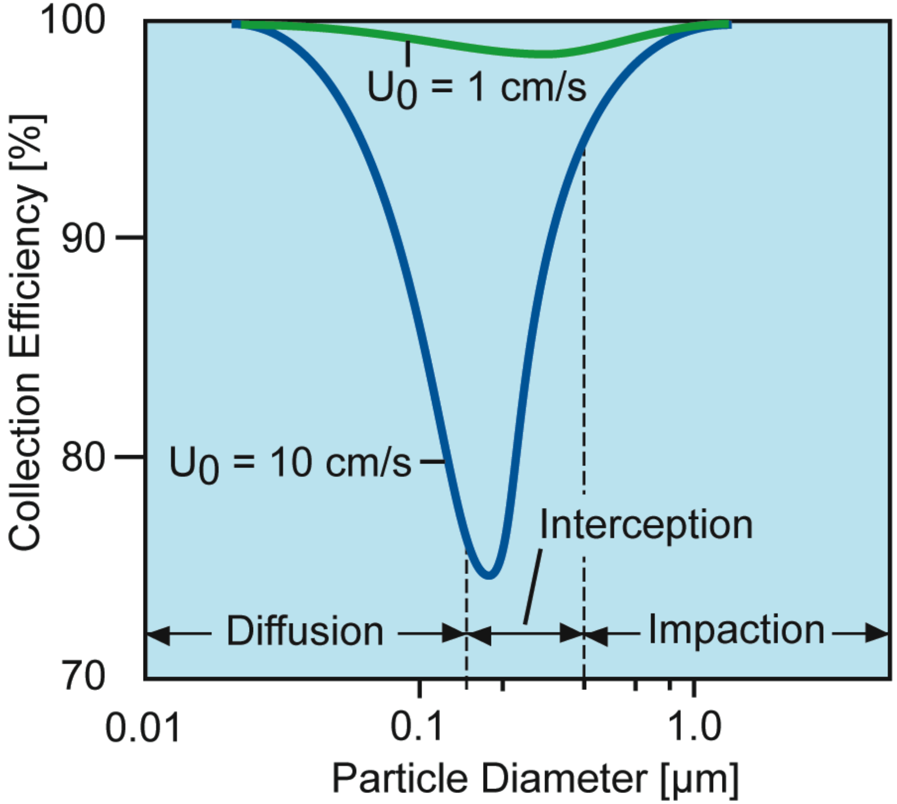
still no equivalent ambient limits

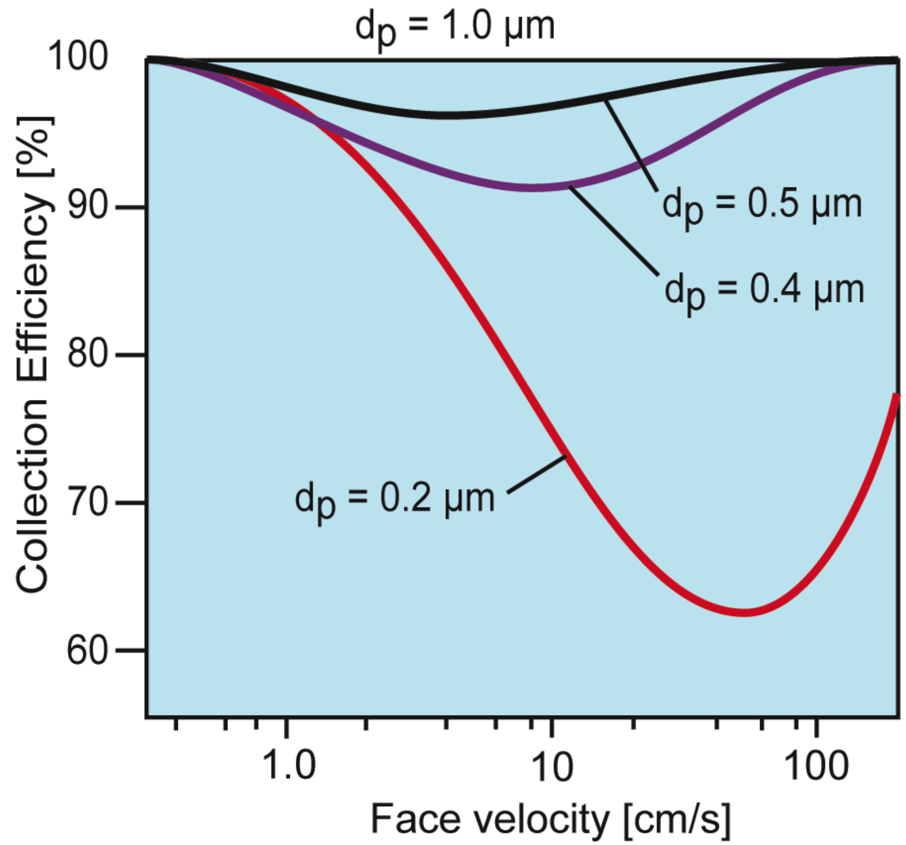
Table 0.3. Summary of good practice statements

UFP	1.	Quantify ambient UFP in terms of PNC for a size range with a lower limit of ≤ 10 nm and no restriction on the upper limit.
	2.	Expand the common air quality monitoring strategy by integrating UFP monitoring into the existing air quality monitoring. Include size-segregated real-time PNC measurements at selected air monitoring stations in addition to and simultaneously with other airborne pollutants and characteristics of PM.
	3.	Distinguish between low and high PNC to guide decisions on the priorities of UFP source emission control. Low PNC can be considered < 1 000 particles/cm^3 (24-hour mean). High PNC can be considered > 10 000 particles/cm^3 (24-hour mean) or 20 000 particles/cm^3 (1-hour mean).
	4.	Utilize emerging science and technology to advance approaches to the assessment of exposure to UFP for their application in epidemiological studies and UFP management.

World Health Organization

Target 4
Avoid typical pitfalls of Nanofiltraton

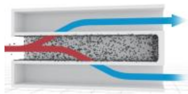


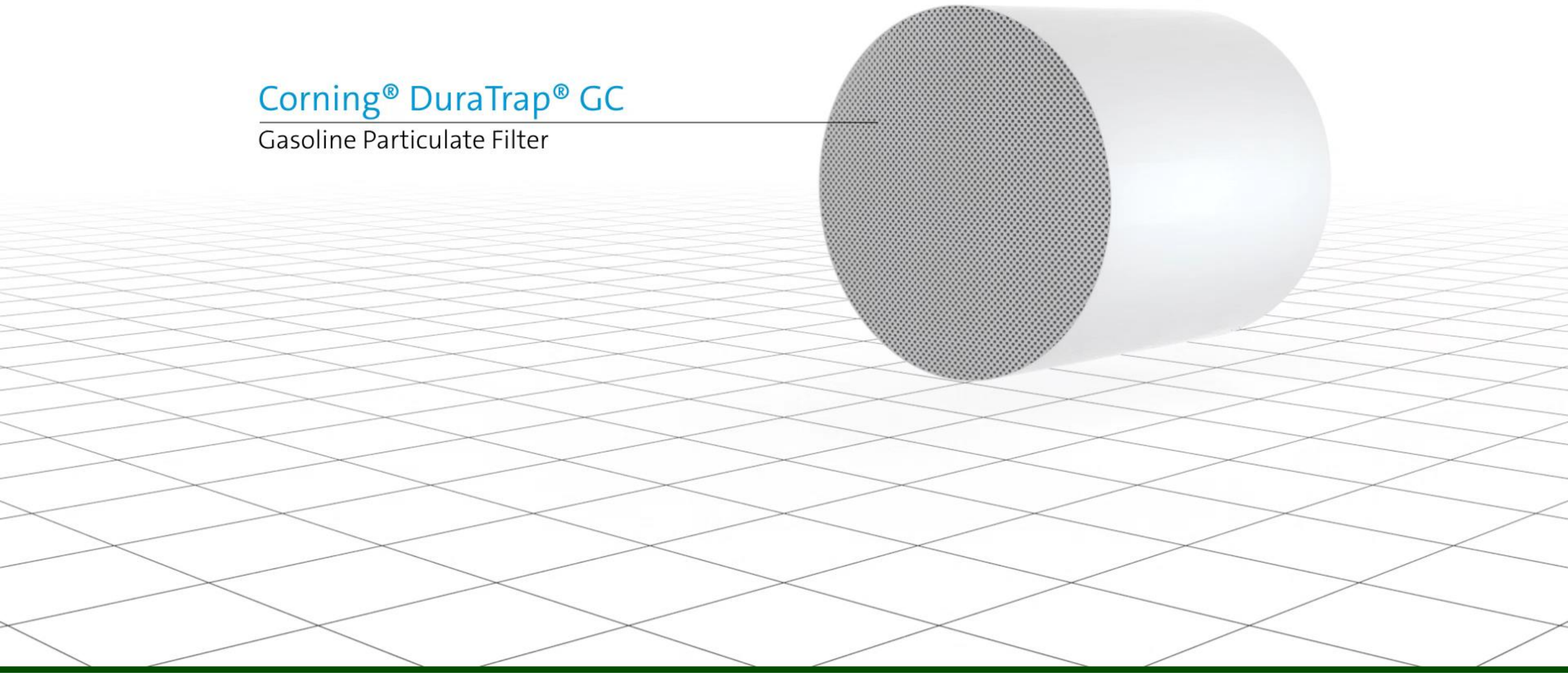


Hinds: Aerosol Technology

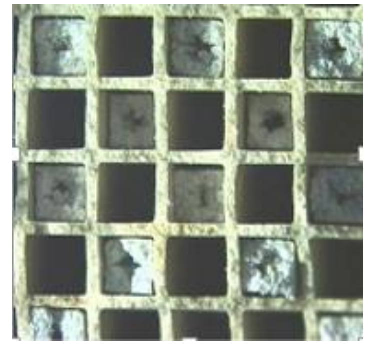
→ Face velosity as small as possible
→ Specific Face Surface as high as possible

Macrostructure CMF





Macrostructure CMF



Typical Cell:1x1 x 150 mm length (minus plugs 125 mm)
- Open Inlet Cross Section 1 mm^2

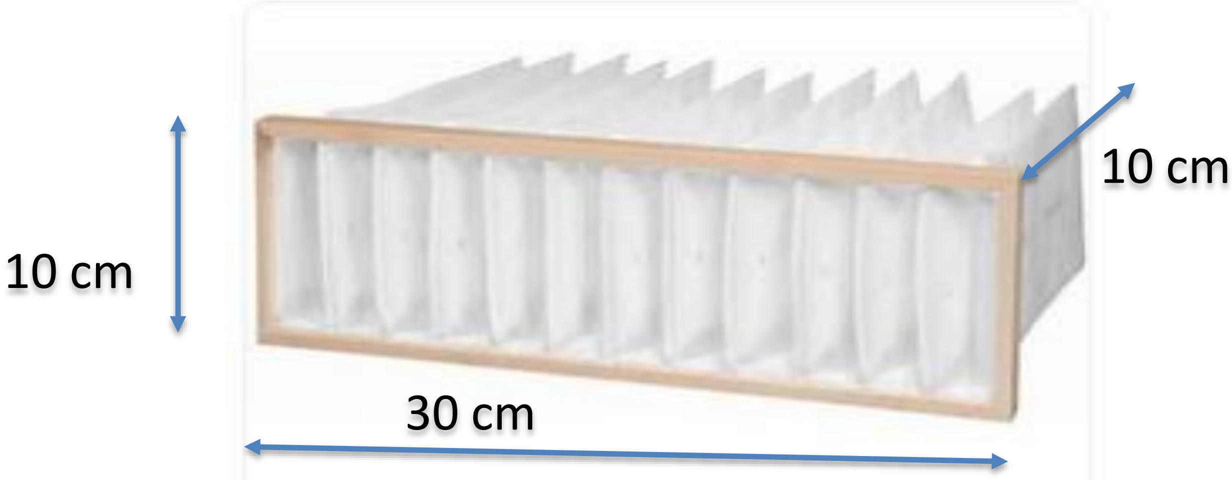
→Cell filtration surface: 500 mm^2 –Increase by factor 500
- Inlet velocity 20 m/s

→face velocity 4.0 cm/s

This decrease of velocity provides residence time for diffucion hence high filtration of nanosize particles.

Real filtration surface for CMF: 1 m^2 per Liter Bulk Volume

Macrostructure TFF



Typical TFF Pocket Structure: 10 pleats per 100 mm length

- Inlet cross section 300 cm^2

→Cell filtration surface: 6000 cm^2 –Increase by (only) 20

- Inlet velocity 10 m/s

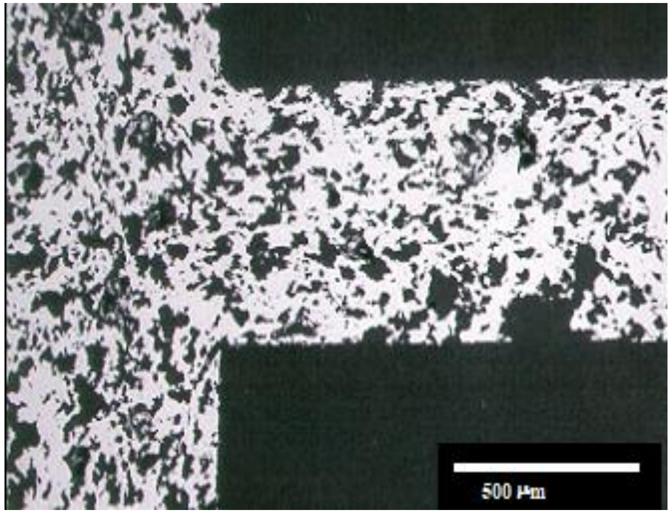
→ Filter face velocity 50 cm/s

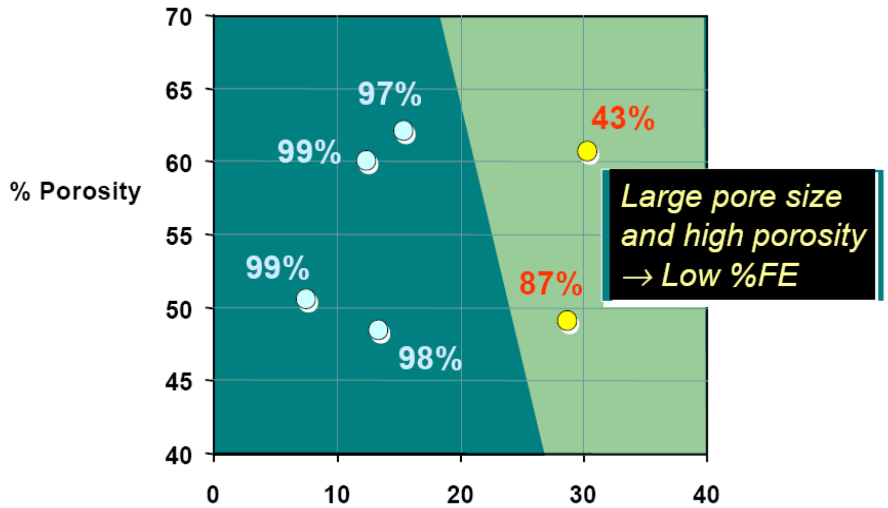
This face velocity is too high to provide enough residence time for diffucion hence volume flow must be reduced.

Overall filtration surface of CMF: 0.2 m^2 per Liter bulk volume

→ For the same face velocity CMF are theoretically 5 times smaller

Microstructure CMF



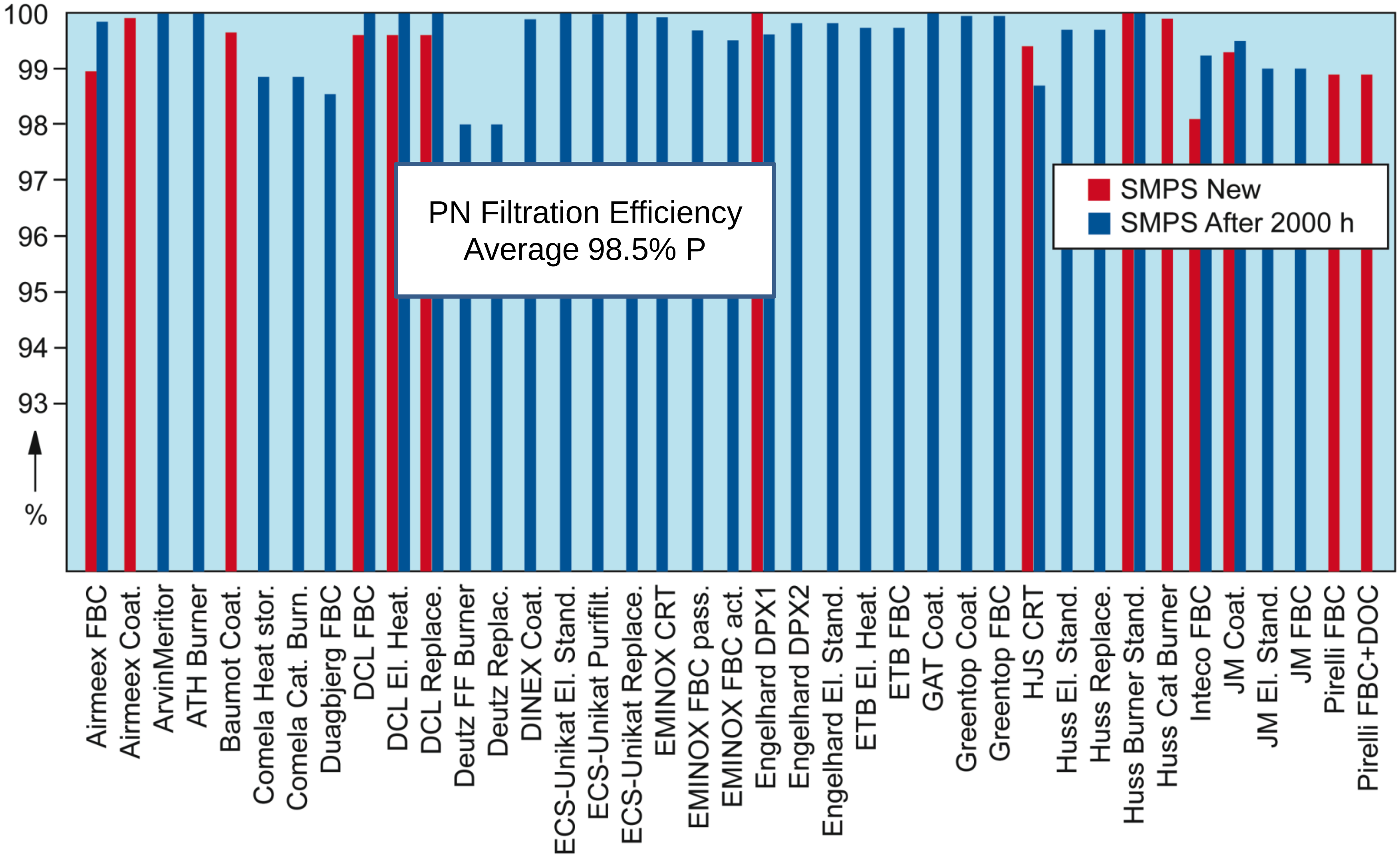


The open pores of the CMF are uniform within a narrow size range of 5-20 µm and are specifically created by incorporating organic components that disappear during firing. With larger pores, separation quickly becomes poor. During operation, the filter cake forms with pores of around 2-3 µm, similar to so-called membrane filters (right). The uniformity of the pore size supports the separation of nanoparticles even at high space velocity.

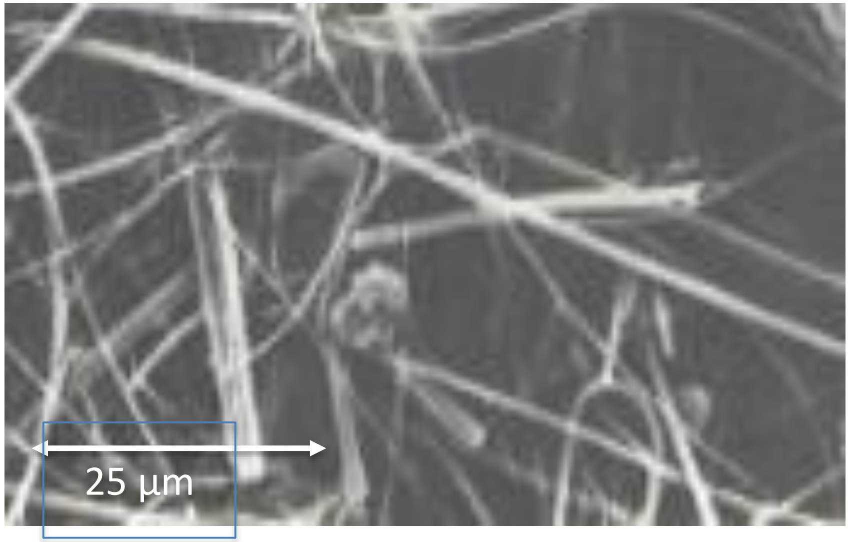
Further Development with Membrane Structure

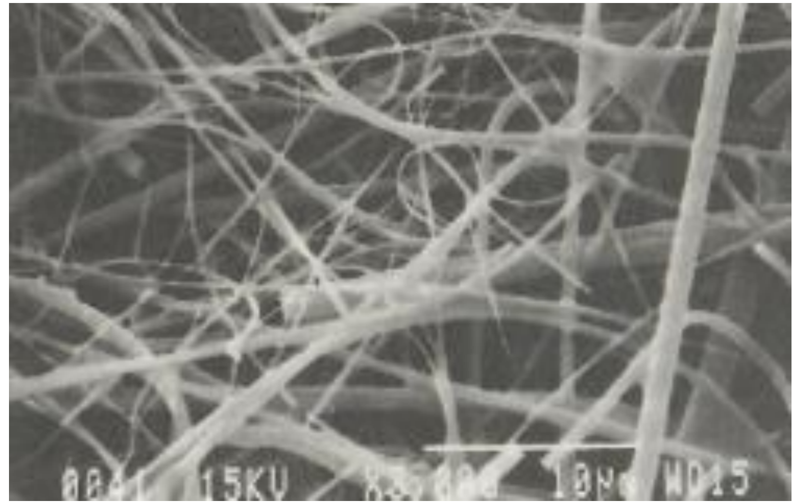
No Aging of CMF after 2000 hrs

VERT-DPF certification

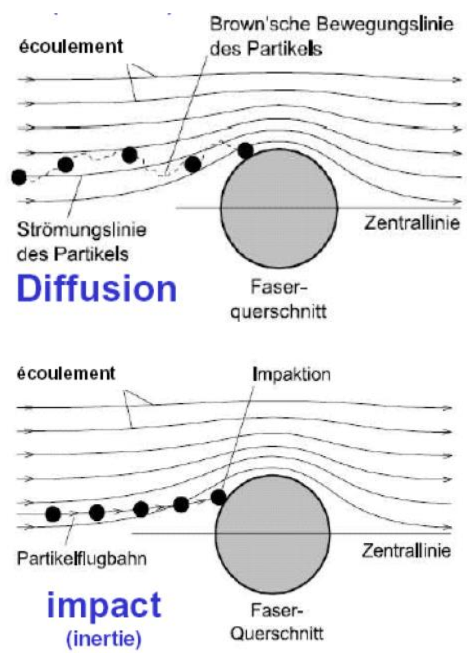


Micostructure TFF



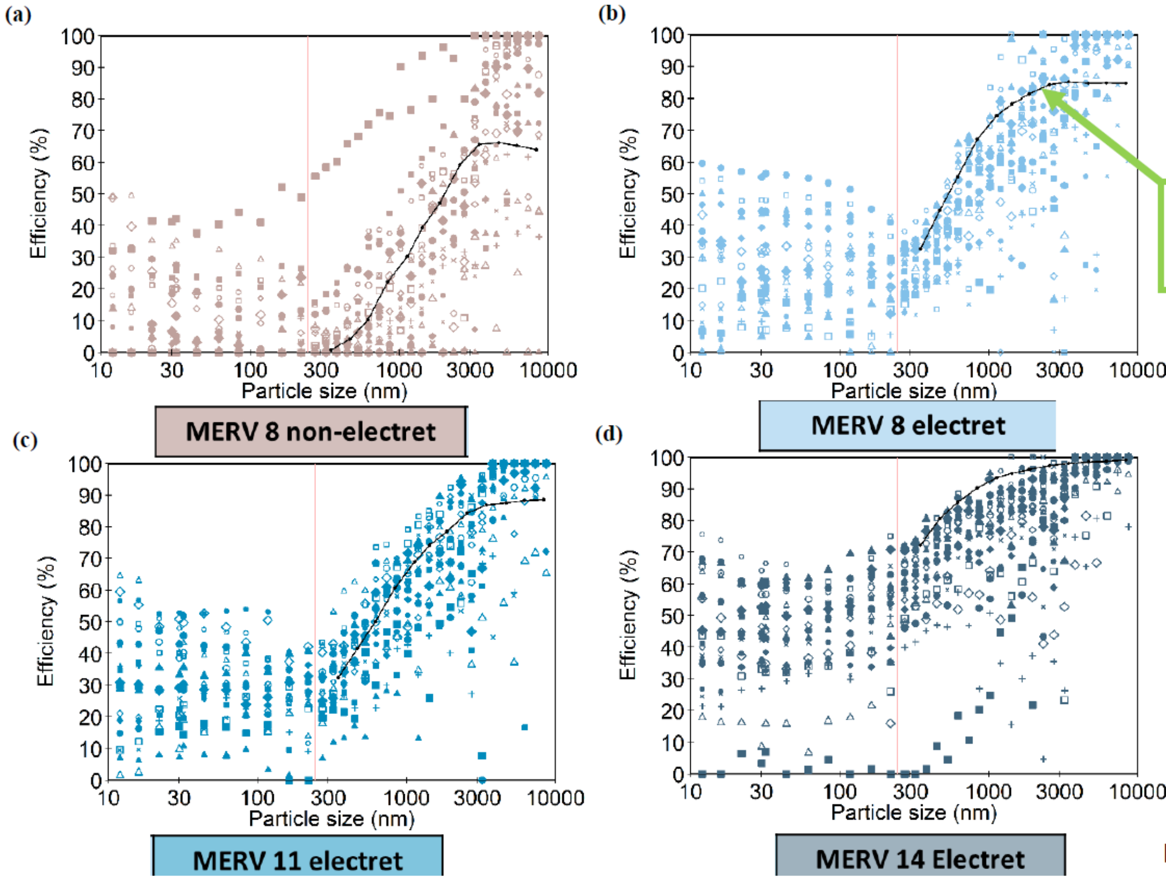


The labyrinth of fiber layers in two high-performance ULPA filters (Hinds on the left, Baraket ETH 1992 on the right), whereby the fibers in the size range of 1-50 µm are randomly layered and mostly bonded together. The variety of fibers and pore geometries broadens the separation range. Porosity up to 98%. Lack of structural strength is a long-term risk.
Large pores result in poor diffusion.



Aging effects are particularly strong at nanosize

because of high velocity, vibration, turbulence, humidity



Filtration <1000 nm by diffusion requires low face velocity HEPA fibre deep bed filters can reach this but In real life they operate at higher velocity thus improve impaction but lose diffusion efficiency

Li and Siegel (2020), *Indoor Air*

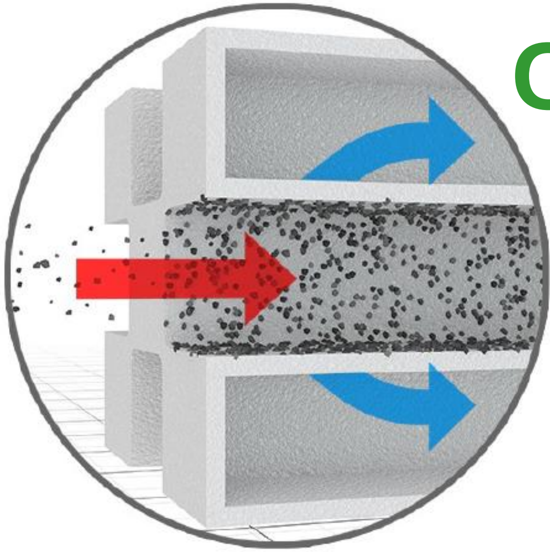
Fine particulate matter filtration and air cleaning in residential environments

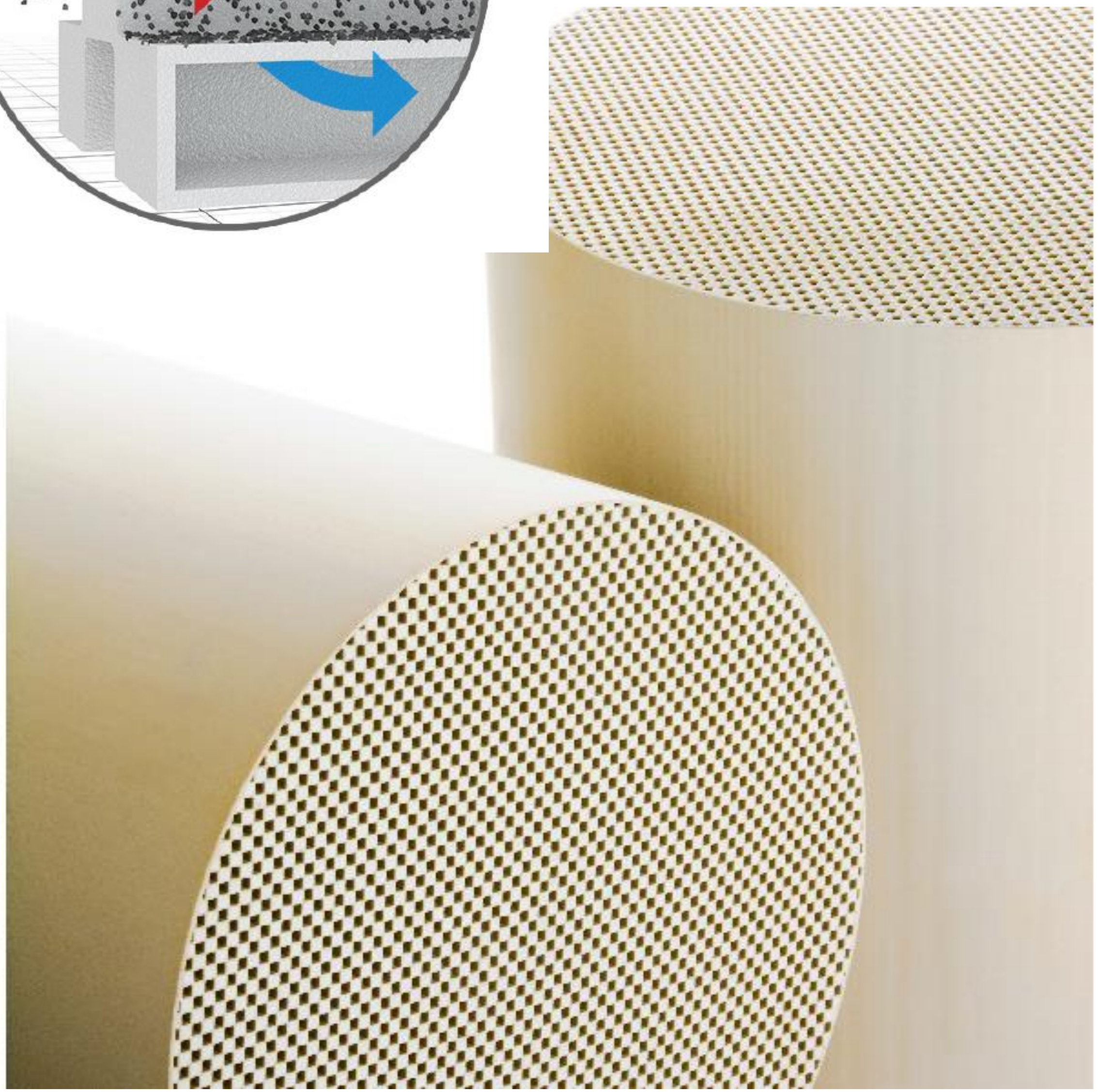
Jeffrey Siegel, jeffrey.siegel@utoronto.ca

Civil & Mineral Engineering
UNIVERSITY OF TORONTO

Ceramic Wall Flow Multicell Filter

invented 1979, now > 300 Mio in vehicles

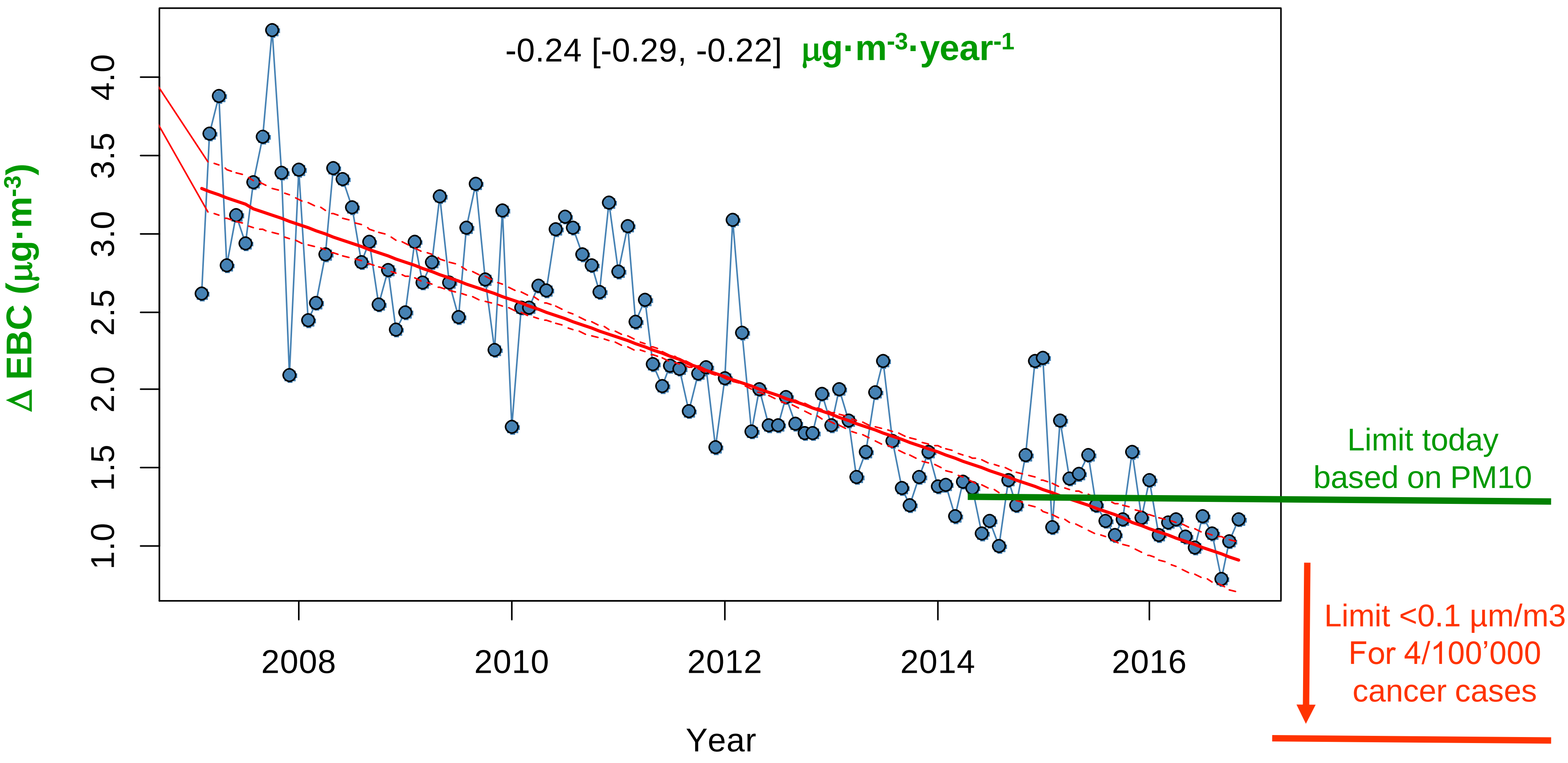




Further useful Properties

- Easy to clean (backflow)
- High storage capacity
- No vibration sensitivity
- No humidity sensitivity
- No corrosion
- Insensitive to aggressive gases
- In use desinfection by heating
- Any shape and size
- Temperature > 1000° C
- Sustainable mass production
- Circular economy
- Life Cycle Emission very low
- Canning Technology available
- Several high quality suppliers
- In process quality control

And the Result:
Cleaning the Air by DPF in Switzerland



CONCLUSION

Ceramic Multicell Filters are an excellent option for Indoor Aair Cleaning compared to Traditional Fibre Filters,

- since they are smaller for the same function
- since they are particularly effective for nanosize traffic related and biogenic toxic particles,
- since they provide longer life, high sustainebility and low operation cost

They are available at high quality and have proven to clean breathing air in traffic and in medical applications

VERT-Team

Schweizerische Eidgenossenschaft
Bundesamt für Umwelt BAFU

M. Wyser

A. Stettler A. Mayer

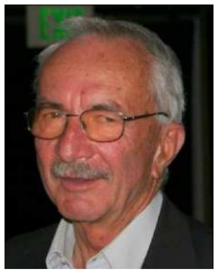
F. Legerer

J. Mooney

AKPF

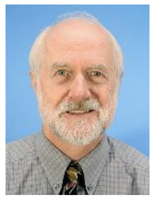
VERT association

krebsliga schweiz



ETH H.C. Siegmann

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich



G. Leutert

F. Jaussi

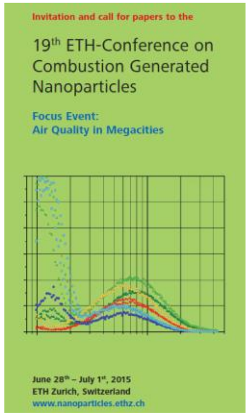
DieselNet

suva

H. Egli

W. Scheidegger

Dissemination & Communication



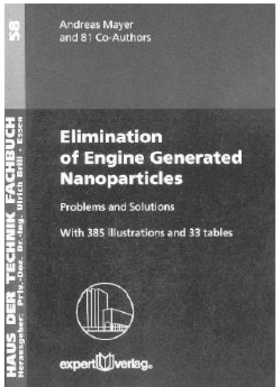
Educational material published

www.naoparticles.ethz.ch
www.vert-certification.eu
www.motorlexicon.de

VERT: 7 books and > 250 papers

NPC: >2500 scientific contributions

VERT-Forum > 450 contributions:



SAE 2011-01-0605

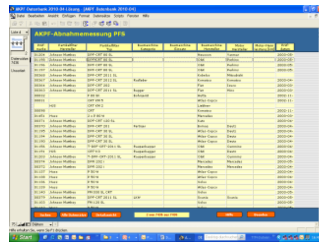
DPF Systems for High Sulfur Fuels

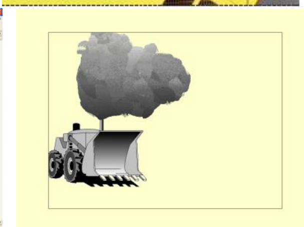
A.Mayer, J.Mooney
TTM, Switzerland, LLC, USA

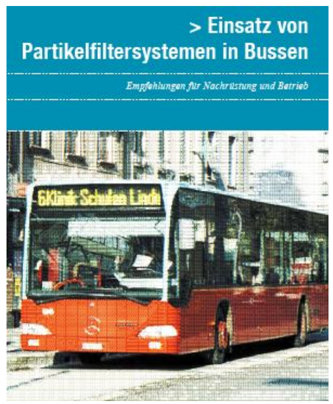
J. Czerwinski, P.Bonsack
AFHB, Switzerland

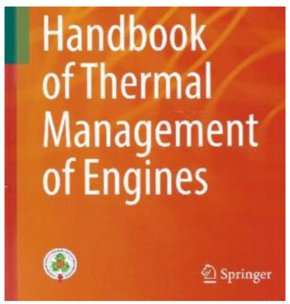
L. Karvonen
EMPA, Switzerland

Liu Xian
VEMC Beijing









Safety is possible.

Checklist

Particulate filters for diesel engines used underground

Basic Internal Investigations

- Keramik Multicell Wallflow Abgasfilter im Vergleich zu Keramikfaserfiltern (Buck); Projekt BMFT 1990-2000)
- Keramikfilter im Vergleich zu Karamikfaser-Wickelfiltern 3M und Hug 1995-2002 (VERT SUVA Berichte)
- Keramikfilter im Vergleich zu Metallfaser-Filtern; VERT Projekt Zweitaktmotoren Teheran 2015-18
- Plissierte Faserfilter für Flugzeugkabinen Belüftung; Projekt NCA/BAZL 2020, Burtscher
- 80 VERT Filter Zertifikationen 1997 bis heute, VERT-Filterliste www.vert-certifizierung.eu;
- Life Cycle Analysis von Keramikfiltern aus VERT Studie AeroSolfd 2024
- Nanofiltration combined with laminar vertical flow / FILTEC, Köln 2022

Literatur

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- AUVA: Luftfiltration, Normen und Nomenklatur 2018
- UNIFIL AG, Prüfverfahren für Luftfilter
- J.Siegel, Toronto: Indoor Air Cleaning 2017
- P.Tappler, Wien: Innenraum-Analytik, Newsletter 2020
- Jodeit 1985, Diss Berlin
- Baraket; Diss 1992 ETH