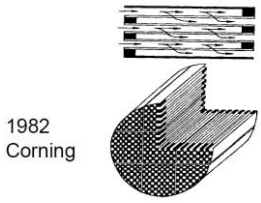
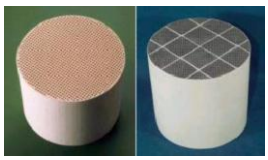
100 Million Particle Filters now Operational in Diesel Vehicles Cleaning City Pollution - a Unique Success for Preventive Medicine

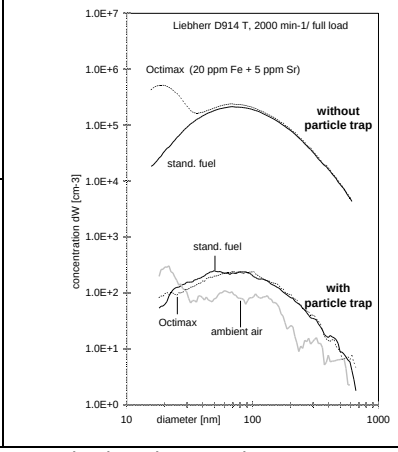
A.Mayer, L.Matthews, M.Wyser, Th.Lutz, V.Hensel. F.Legerer, J.Czerwinski, M.Kasper - VERT



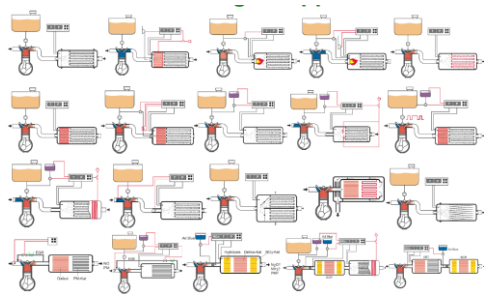


History: based on the concept of the cellular substrate of the TWC (1976 by J. Mooney - right) the DPF was ready 1982, specified for Ultrafines 1995 by A.Mayer (middle) and implemented by VERT (Legerer) 1997

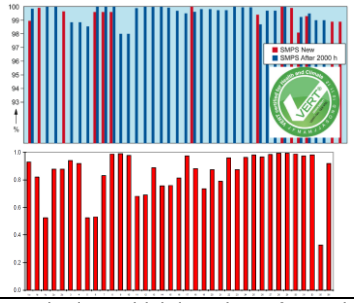
Filtration of Nanoparticles is Science (Matter, Kasper)
Combustion generated solid particles appear in the size range of 10-500 nm which is exactly the most sensitive size range of the lungs and the most difficult for filtration with diffusion for the smaller ones, impaction for the larger and a critical overlap in between. Pore shapes, size distribution around 10 µm and face velocity < 10 cm/s are required for high efficiency which must be controlled per size fraction for the clean and the soot /ash loaded filter. This is only possible by number counting while excluding all effects of nucleation. Filter control unspecific to size is useless.



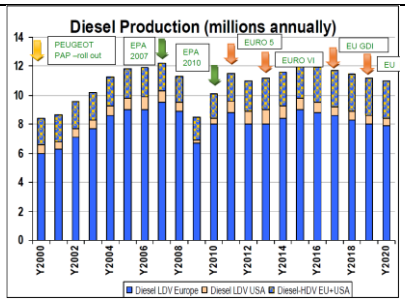
Abandon the criterion "particle mass" PM [g/kWh], because it does not respect size and substance and to introduce number count as new emission criterion PN [#/kWh] for internal combustion engines was the key element for progress in emission mitigation of engines. Switzerland implemented this step first at the working place in 1995 with the VERT-project for DPF in tunneling, followed by regulation for construction and public transport and demonstrated the feasibility in all applications, even ships and rail. Swiss NanoMet, new particle sizing and counting instrument became the "golden instrument" (Kasper) for the UN-ECE-PMP program and with this EU has introduced PN criteria for Euro 5/6 and Euro VI in 2011 and 2014. From the first VERT pilot fleet with 10 DPF on construction machine in 1996 we have now reached 100'000'000 DPF in all LDV and HDV. NRMM is following and petrol engines will also be equipped with filters from 2018. Efficiency of filtration is a revolution with > 99% and detoxification by catalysis is a very powerful side effect. Solid particles need to be identified, measured, filtered, eliminated.

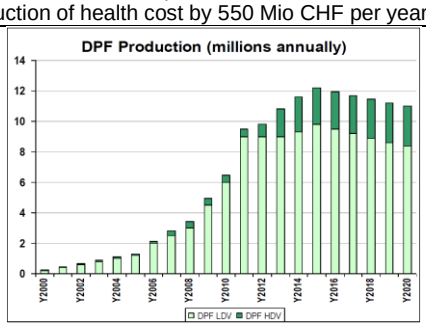


DPF System Design (left) challenged engineering creativity because of the multitude of applications and operation conditions. Regeneration by burning the soot during operation required new soft- and hardware.
Filtration (top right) proved to be > 99% for 75% of all VERT-certified DPF systems new and after 2000 op.hours
Conversion of PAH high by catalysis - no generation of secondary toxic substances (Heeb)

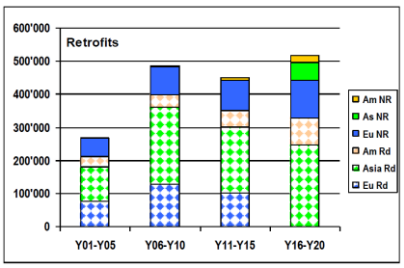


DPF are not legislated for new Euro 6/VI vehicles but as soon as the EU-commission adopted the PN criterion, which is orders of magnitudes more sensitive than the traditional gravimetric PM, the limit values could be defined so low that very effective DPF became state of the art. After **the PSA rollout of 607 in Mai 2000** stepwise introduction by competitors increased the numbers reaching 1 million per year in 2004 to now over 10 million in passenger cars and HDV (Matthews). More will come with petrol cars and non-road vehicles very soon cleaning the breathing air in the cities**.** Kanton Zürich calculated in Mai 2018 a reduction of health cost by 550 Mio CHF per year → probably 400 premature death less!





Retrofit



However
- ambient air quality is still defined by PM – the effects of these 100 Mio DPF is hardly visible in official PM10 or PM 2.5 data
- epidemiology is still correlating health effects with PM10 – particles which not even pass the alveoli membranes - anachronistic and not only misleading the health effect research but also policy makers.
- legislation has not introduced yet PN in the inspection routines so failures cannot be properly detected
- the need for retrofit of the in-use fleet is not understood by the clean air administration
- large emitters like aircraft, marine and hand-held are lagging behind in international regulation and state of the art of vehicle Diesels
- USA is delaying this emission reduction process by not accepting PN

Emission Stability requires Quality Control: New technology requires careful quality control. Next step must therefore be the PN control during periodic technical inspection → NPTI
The VERT NPTI-Project has reached agreement on metrology and testing procedure with all stakeholders and the Netherland will be the first country to introduce this powerful control strategy in 2019

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