

10. VERT-Forum – March 14th 2019



MEMBRANE PARTICLE FILTERS with PULSE CLEANING for MARINE and OTHER APPLICATIONS

Thomas Lutz / Andreas Mayer

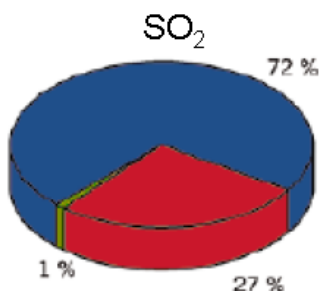
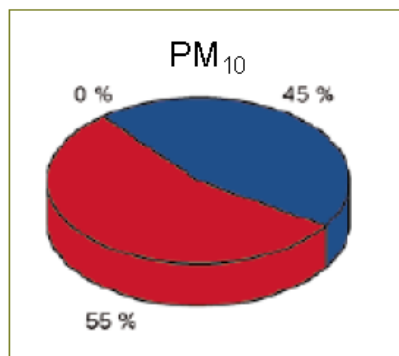
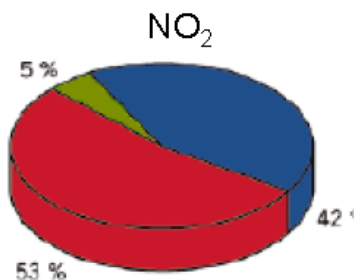
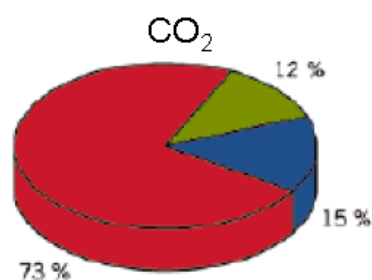
○ **BACKGROUND and TARGET**

- Marine contribution to global PM-burden
- Marine diesel fuel properties → *sulfur* and *ash*
- PM characteristics
- Why not standard wall flow DPF?
→ MAN experience (Lauer, 16th ETH-NPC)
- Membrane filter structure
- → **A membrane filter based concept**

Three Major Sources of PM and PN

MTZ 2011 – one large ship equals 80'000 trucks

by Mass (PM₁₀)



■ Road Traffic
 ■ Aviation
 ■ Marine

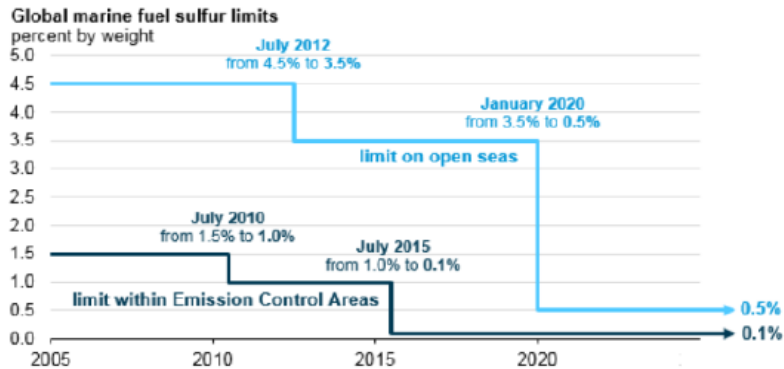
by Number (PN)

Road traffic
 10^{25} UFP per year

Aviation
 10^{26} UFP per year

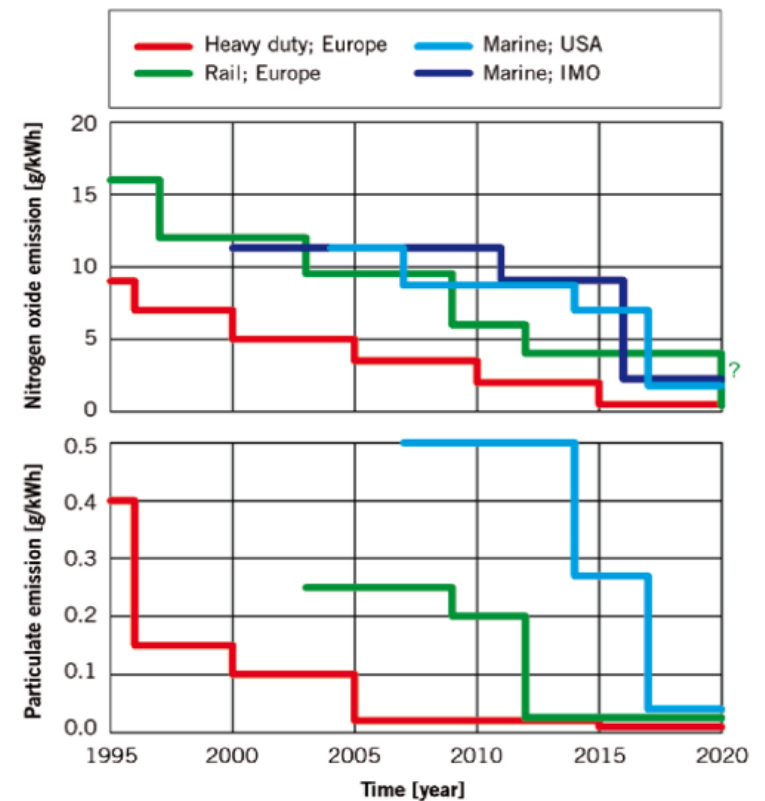
Shipping
 10^{26} UFP per year

EMISSION LIMITS



Source: U.S. Energy Information Administration, based on International Maritime Organization (IMO)

The International Maritime Organization (IMO), the 171-member state United Nations agency that sets standards for shipping, is set to reduce the maximum amount of sulfur content (by percent weight) in marine fuels used on the open seas from 3.5% to 0.5% by 2020. These regulations are intended to reduce sulfur dioxide, nitrogen oxides, and other pollutants from global ship exhaust.



ON-BOARD PM EXPOSITION 'AIDA Prima', launched 2014



E.g. ice rink behind the stack:

Measured values:

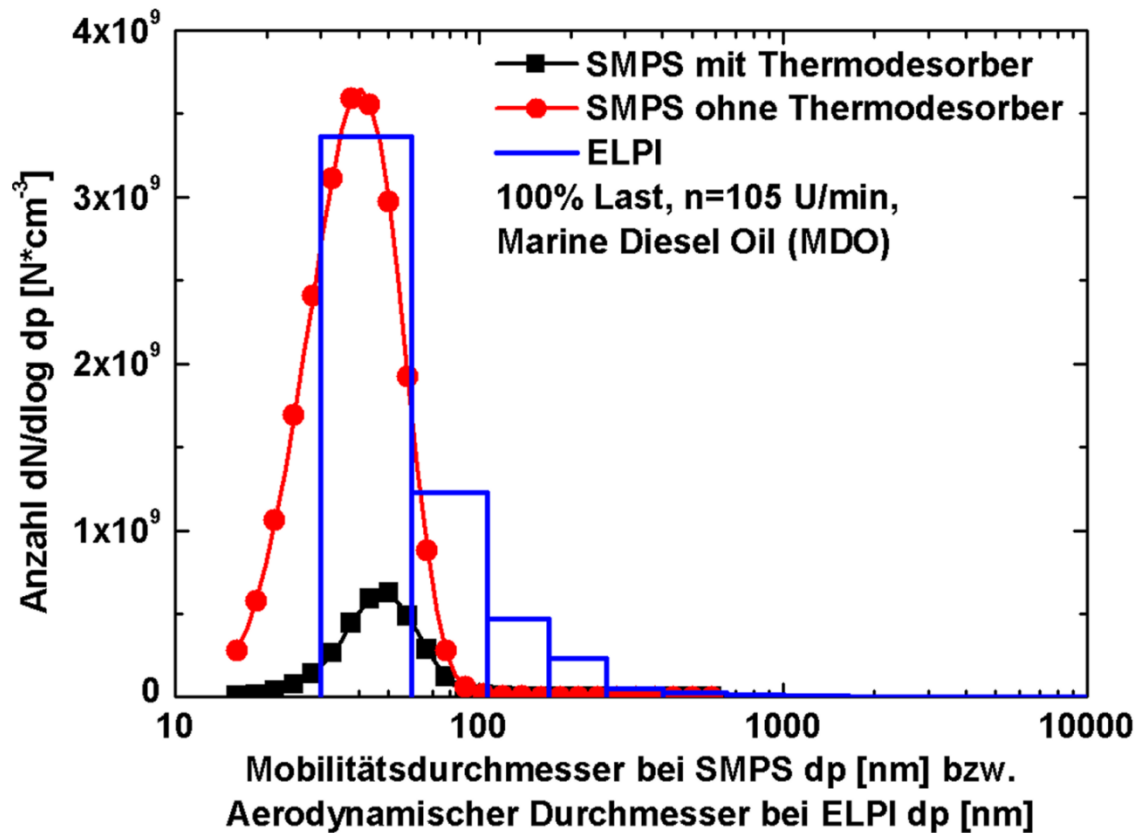
½-h-average: 68'000 #/cc

peak values: > 250'000 #/cc

Source: J. Kersten, plusminus/ARD, March 2017

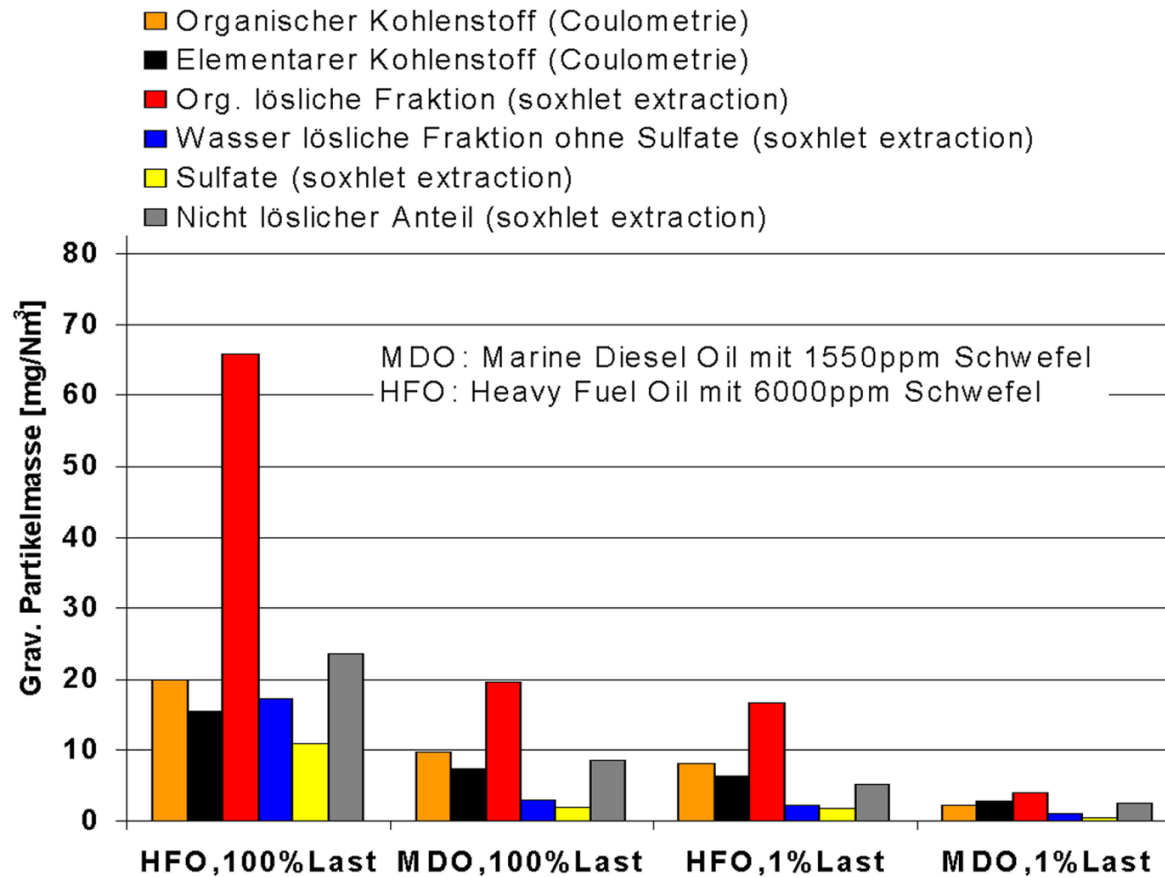
TYPICAL PARTICLE SIZE DISTRIBUTION

SULZER 4 RT-flex 58T-B - MDO



Source: KTI Project 4207.2 KTS

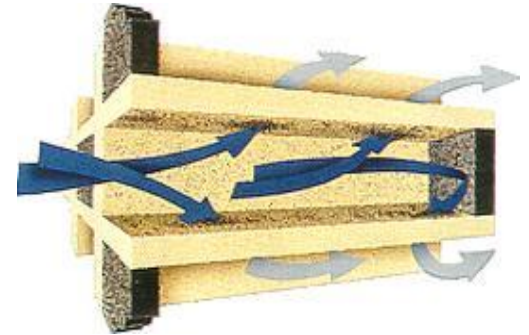
PARTICLE COMPOSITION



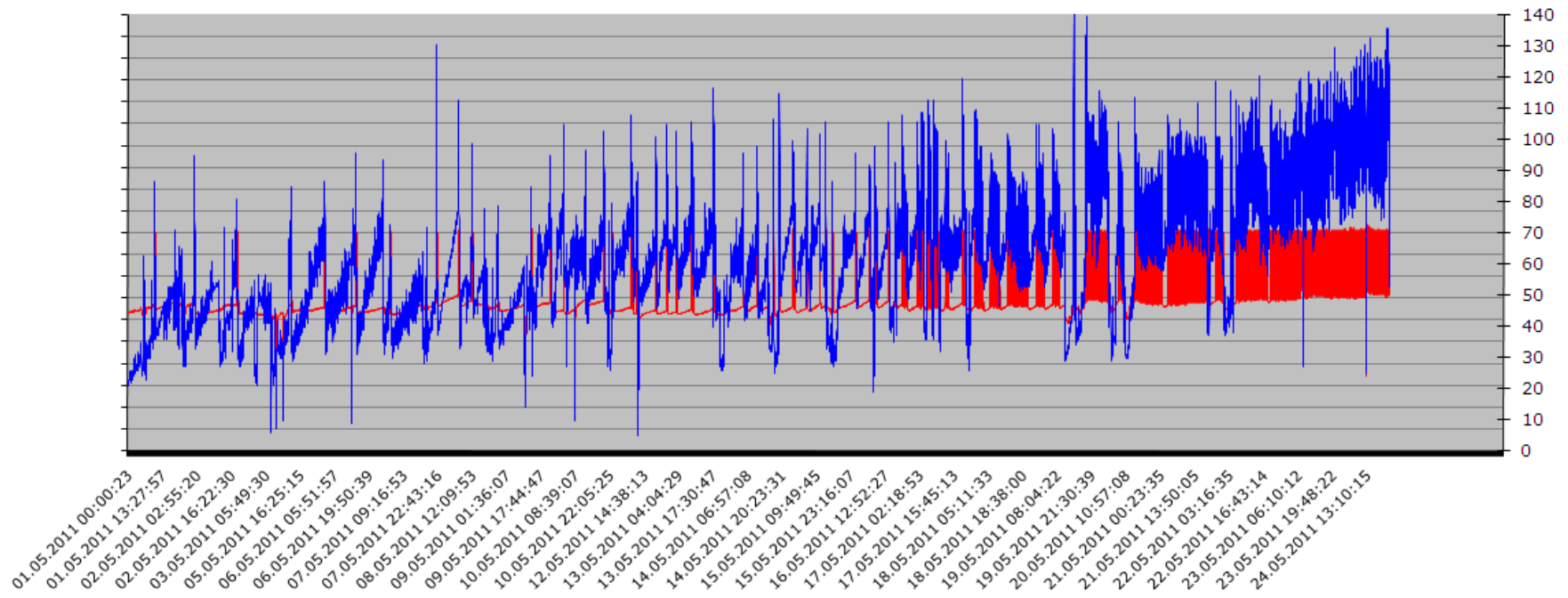
Source: KTI Project 4207.2 KTS

DPF BACKPRESSURE DEVELOPMENT

Irreversible due to high ash content



— Backpressure [mbar]
— Temperature at filter inlet



○ **CRUCIAL REQUIREMENTS for MARINE DPF**

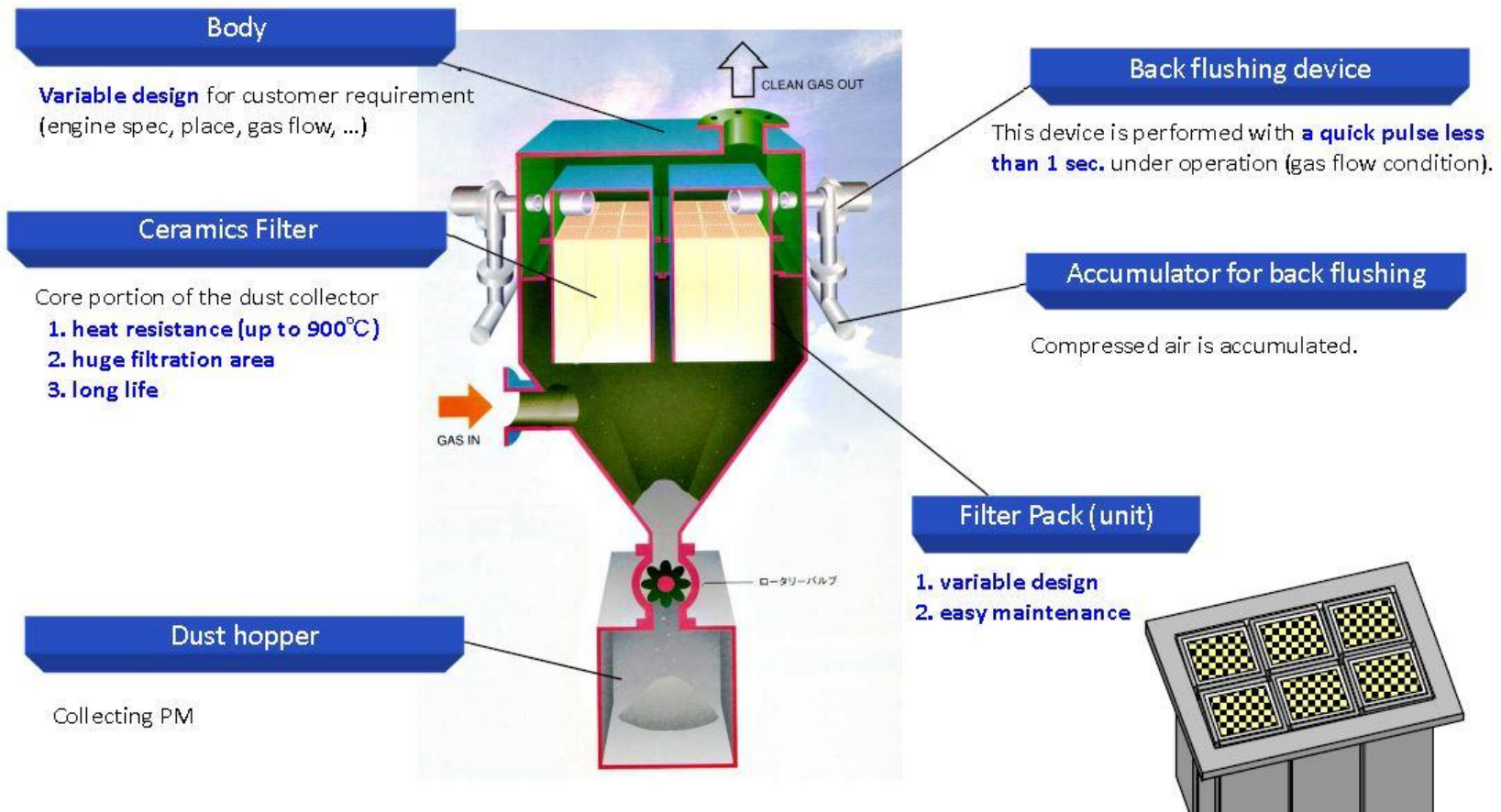
- Sulfur tolerant > 20'000 ppm
- Ash tolerant > 20 times more ash than HDV
- Regeneration below 250°C (2-stroke engines)
- OC/EC > 4 → sticky particles
- DOC sulfur tolerant and not plugging
- Low backpressure (< 100 mbar)
- **Continuous soot + on site ash cleaning**



Ceramic membrane filter with pulse cleaning

DRY DUST COLLECTOR for HIGH-TEMPERATURE GASES

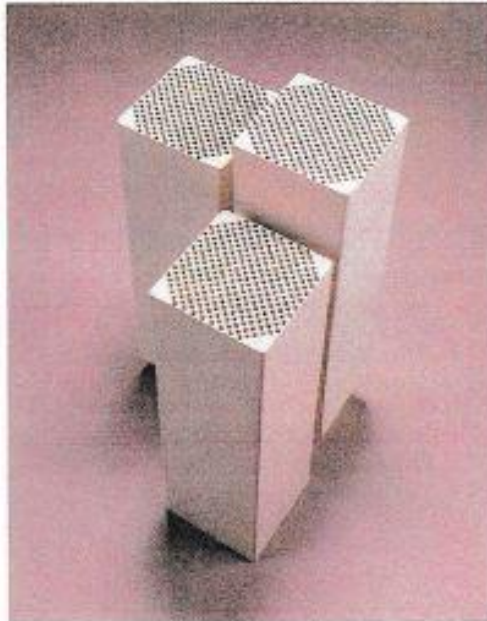
NGK CERALLEC System



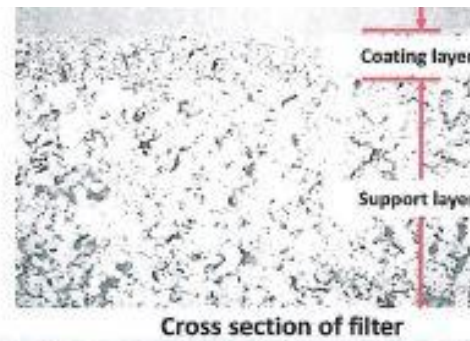
Source: NGK 2016

○ NGK MEMBRANE FILTER

Characteristics of ceramic filter



| | |
|--|--|
| Material | Cordierite |
| Working temperature | Up to 900 °C |
| Dimensions | 150□ × 500L |
| Cell pitch / Filtration area | 4mm / 4.0m ² 6mm / 2.6m ² |
| Pore size (support layer) (coating layer) | Approx. 15μm Approx. 5μm |
| Porosity | 45% |
| Coefficient of thermal expansion | 1 × 10 ⁻⁶ /°C |



Source: NGK 2016

○ A NEW CONCEPT for a MARINE DPF SYSTEM

- DOC

- large pore foam structure: insensitive for plugging
- sulfur tolerant coating – and/or FBC
- converts OC → drying soot; agglomerating particles, heating gas

- DPF

- very fine pore membrane structure
- high space velocity permitted → small bulk size
- high frequency on site pulse cleaning to keep backpressure small
- *pressure pulse formation* and wave propagation will be *crucial*
- modular design

- SCR

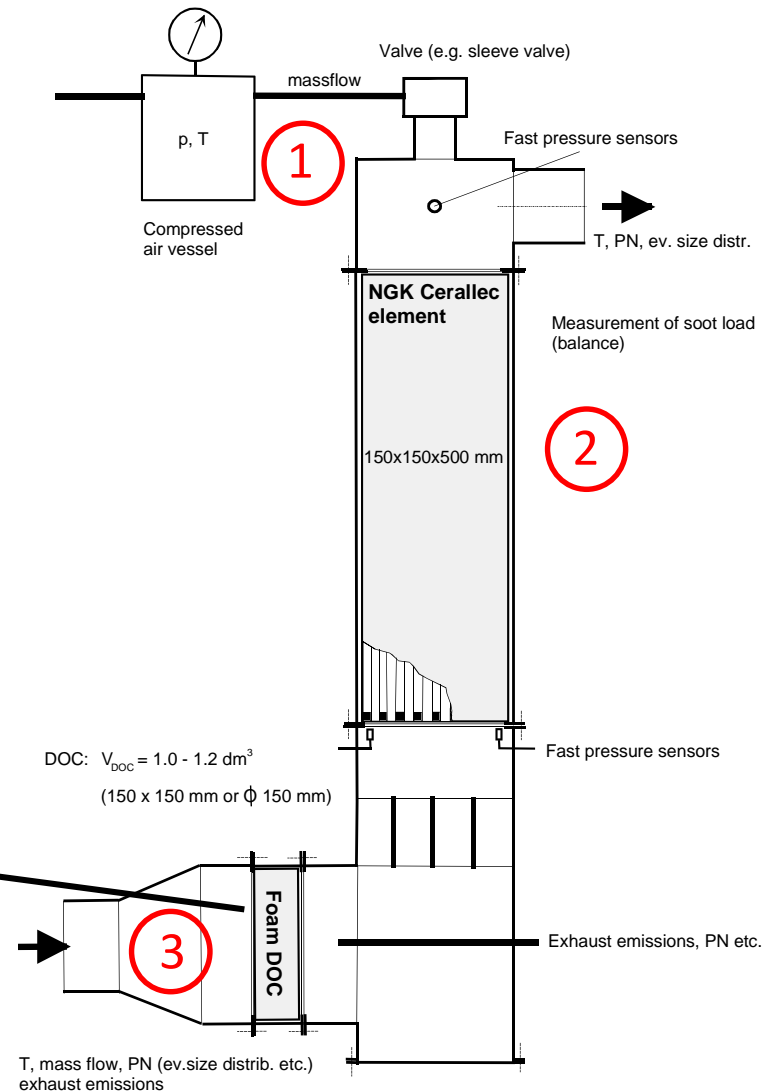
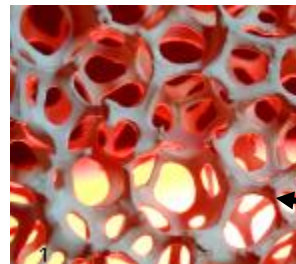
- high cell density due to clean gas

○ FILTER SYSTEM TEST RIG (sketch)

1 Pressure wave generator

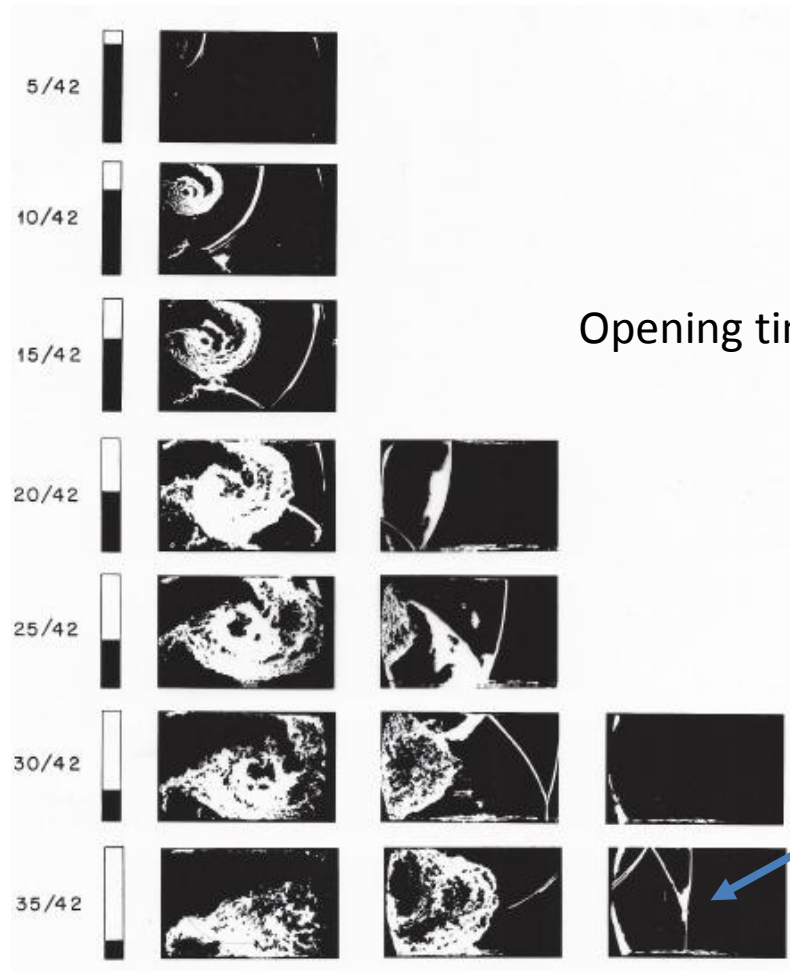
2 Membrane filter

3 Foam DOC



SHOCK WAVE GENERATION

Sleeve valve
movement

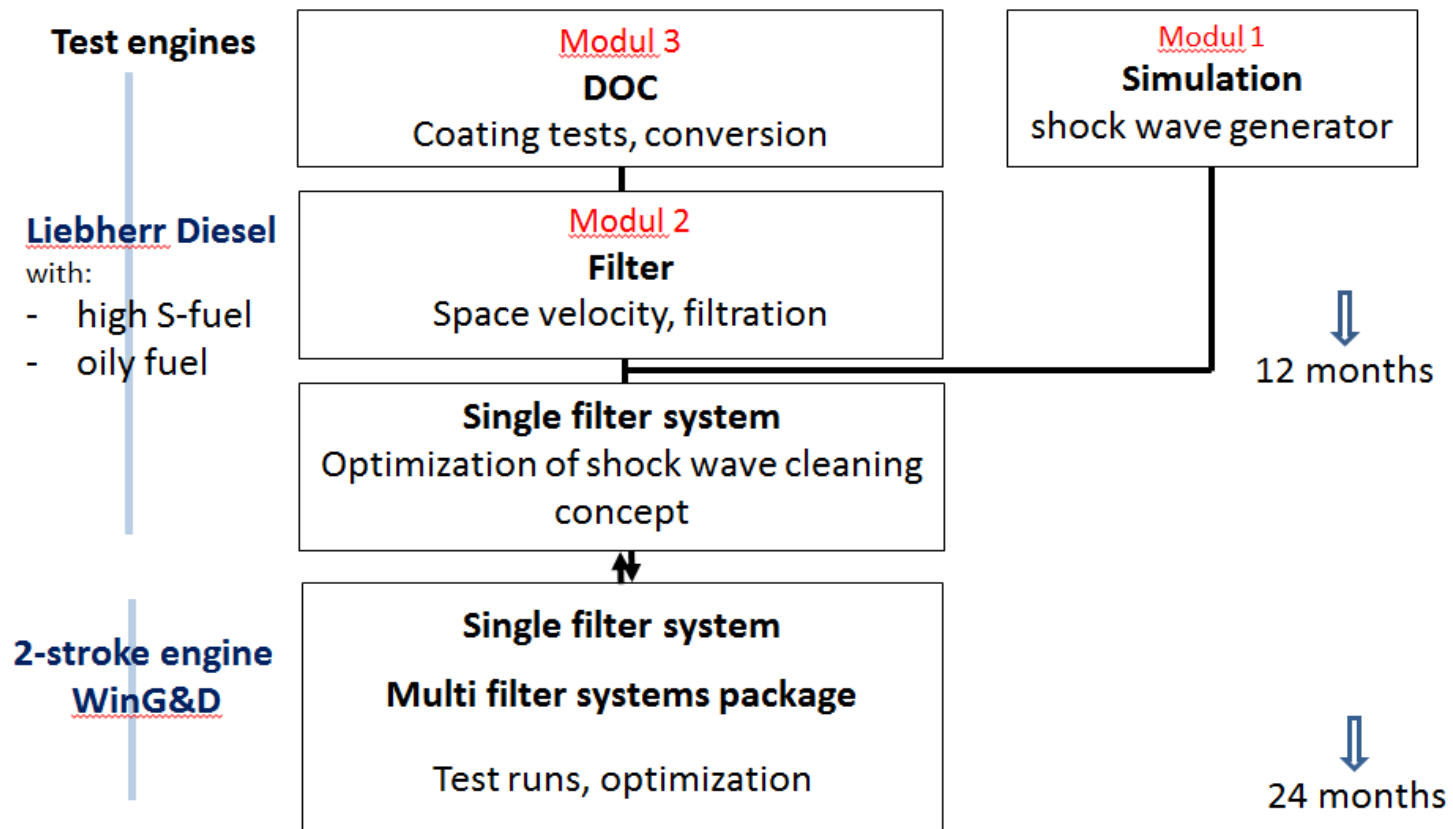


Source: BBC Complex research



WORK PACKAGES

Two years from January 2019



PARTNERS

- **Research Partners**

- AFHB
- Combustion and flow solutions GmbH

- **Industrial Partners**

- NGK
- LIEBHERR
- WIN G&D
- Pure Clean Air
- UMICORE
- Fraunhofer Institut

- **Financing Partners**

- BAFU-Technologiefonds (CHF 170'000)
- VERT (CHF 45'000)

- **Project Management:** A. Mayer, Th. Lutz

○ A Final Remark

The ability of *on site ash removing* from the DPF might also be an attractive solution for *construction machinery* and *locomotives*

➡ **Towards a blue sky and blue water**



Thank you for your attention