

# BC AFTER DIESEL PARTICULATE FILTERS

6th ICCT Workshop on Marine Black Carbon Emissions 17<sup>th</sup> of September 2019 Helsinki, Finland Dr. Daniel Peitz



#### **KEY FACTS**



Turnover	CHF 64.5 Mio.*
Employees	250
Headquarters	Elsau, Switzerland
Subsidiaries	us, nl, de, it, cn
Certification	ISO 9001 / DIN EN 15085

\*2018

#### •faurecia inspiring mobility

Turnover	€ 17.5 billion*			
Employees	122.000			
Headquarters	Nanterre, France			

More than 300 sites including 35 R&D centers in 37 countries





## INNOVATION FOR YOU BASED ON EXPERIENCE





Klinger Group







#### PRODUCT PORTFOLIO- OVERVIEW



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		Dowernlante	combikat™	Power range	Installed units	Installed power	
nary	•	Cogeneration plants Emergency power		200 – 40,000 kW	2,100	9.5 GW	$\odot$
Statio	•	CO <sub>2</sub> -fertilizing in greenhouses	COdiNOX"	200 – 6,000 kW	1,800	3.2 GW	
	•	On- and offshore vessels Cruise liners Freight vessels	clean4marine"	500 – 40,000 kW	550	1.5 GW	٢
<u>0</u>	•	Yachts Inland water vessels Ships	nauticlean*	200 – 9,000 kW	850	600 MW	
Mobi	•	Locomotives Track construction machines Railcars	B C C C C C C C C C C C C C C C C C C C	200 – 5,000 kW	1,100	1,200 MW	
	•	Construction machines Commercial machines Trucks & buses Agricultural & forest machines	mobiclean" R	15 – 5,000 kW	More than 37,000	n.m.	<b>b</b> <b>hug</b> engineering

# DIESEL PARTICULATE FILTER (DPF)

- Extensive experience for high speed engines on ULSD/MGO
- First projects for small (< 3 MW) medium speed engines on MGO/MDO
- Under development for large (> 3 MW) medium speed engines on MGO/MDO
- Medium speed engines on HFO under testing, but so far not promising
- Low speed 2-stroke engines so far out of discussion (commercial & technical reasons)



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wall flow filter principle

Contaminated exhaust gas



black carbon

## MARINE DPF SYSTEMS





diesel burner for regeneration (burner pipe or chamber)
reactor housing with filter cassettes (various aspect ratios)
→ modular setup for flexible arrangement

# Yacht/inland water vessel DPF+SCR

#### nauticlean™

Exhaust Gas Purification System Diesel Particulate Filter with Active Regeneration and Selective Catalytic Reduction



hugengineering.

Reactant Air

Fuel

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# MARINE DPF EXPERIENCE







## MOTIVATION



Clean decks and uppolstery «no visible black carbon»







## **REGULATION IN SWITZERLAND**



PN (particle number) limit of 250'000 #/cm<sup>3</sup> for all NRMM VERT certificate accepted (DPF with >97% PN reduction) → wall-flow DPF for locomotives, construction machinery, vessels, ...



# EXPERIENCE IN SWITZERLAND

Field conditions: High speed diesel engines up to few MW EN 590 diesel fuel required (max. 10 ppm sulfur)

Only clean exhaust is measured by CPC (condensation particle counter), all particles above 23 nm are counted, independent of particle composition

accredited measurement devices are typ. inappropriate for raw exhaust
→ only approximations for relative PN abatement in the field (but >97%)
→ no monitoring of black carbon emissions or abatement efficiency

# SWISS APPLICATION EXAMPLE



Annual check with additional raw gas measurement:

1'500 kW high speed diesel engine with active regeneration DPF

30% engine load: 8'300'000 #/cm3 (raw gas) 36'700 #/cm3 (clean gas) → 99.6% PN (particle number) abatement based on CPC measurement

# LUXURY YACHT WITH DPF



SCR spot checks, additionally Hug-conducted DPF evaluation

270 & 200 kW high speed diesel engine gensets with active regeneration DPF Engine operation on ISO 8217 DMA («MGO») with 1000 ppm sulfur (ECA 0.1%)

Measurement with AVL MSS (PAS measurement principle)

Engine	Load	Raw	Clean	Abatement
270 kW	50%	42 mg/kWh	0.30 mg/kWh	99.3%
	75%	47 mg/kWh	0.26 mg/kWh	99.4%
200 kW	50%	70 mg/kWh	0.13 mg/kWh	99.8%

→ >97% black carbon abatement based on PAS measurement

# LAB TESTING OF DPF



Filtration efficiency assessment by different analytics

Cambustion Diesel Particle Generator (DPG) test setup (controlled hot air flow with EN 590 diesel burner-generated soot)

Measurement analytics:

PN – condensation particle counter (CPC) PM (soot) – AVL micro soot sensor (MSS) PM (soot) – AVL smoke meter (FSN)

Filter cassette taken from a luxury yacht after 6'000 h field operation Soot filter cake was burnt via a regeneration before start of test



→ >97% abatement based on all measurements after <200 s</p>

# FIELD MONITORING



100's of marine DPF installations available, but no PM, PN or BC regulation  $\rightarrow$  no scientific monitoring of emissions or abatement efficiency

Equipment logistics, space requirements for installation, sampling possibilities on site, operational restrictions, timetables and expenses associated with field measurements challenging as solely voluntary data acquisition

#### → Invitation for collaboration partners to confirm field performance

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## NEXT STEPS

Besides luxury yacht and NRMM exposed applications new market drivers:

- Customers asking for «getting the job done, but green»
- Passengers caring about health and environment
- Classification notations such as «ultra low emission vessel ULEV»

#### → DPF spreading to medium speed diesel engine applications

DPF integration requires rethinking of engine operation, e.g. fuel & lube\*

\* K. Christianen, Y. Loulidi, D. Peitz, L. Mattheeuws, T. Berckmoes Integration and Matching of Diesel Particulate Filters for ABC Medium-Speed Engines, CIMAC Congress 2019, paper no. 361. 17



## NEXT STEPS



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#### Horizon 2020 project «LeanShips»

Target was a cruise ship DPF for HFO with automatic ash removal

However, ash removal later limited to ISO 8217 DMA (MGO) and DMB (MDO) due to field trial results

Prototype in operation at Hug, but limited commercial interest due to exclusion of HFO operation



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# Thank you for your attention.

