

BC AFTER DIESEL PARTICULATE FILTERS

4th Mediterranean Shipping Conference

Marine Black Carbon Emissions

20th of November 2019

Piraeus, Greece

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***hug*engineering.**
A FAURECIA COMPANY

KEY FACTS



Employees	250*
Headquarters	Elsau, Switzerland
Subsidiaries	US, NL, DE, IT, CN
Certification	ISO 9001 / DIN EN 15085

*2018



Turnover	€ 17.5 billion*
Employees	122.000
Headquarters	Nanterre, France

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

*2018



INNOVATION FOR YOU BASED ON EXPERIENCE



1988
Urea-operated
DeNOx System ,
Schaffhausen



1992
SCR
Marine
System



1993
COdiNOx
System,
Zuurbier



2003
Serial order DPF,
SBB locomotive



2005
DPF installation
Megayacht,
MY White Rose of
Drachs



2014
1st ultra-low NOx
powerplant



2015
IMO Tier III
certification
nauticlean™

INNOVATION

COMPANY DEVELOPMENT

1983
Foundation
Company



2011
Acquisition by
EringKlinger
Group



2016
Acquisition of COdiNOx
Beheer Group,
Netherlands



2018
Acquisition by
Faurecia S.A.



PRODUCT PORTFOLIO- OVERVIEW

Stationary



- Power plants
- Cogeneration plants
- Emergency power



Power range
200 – 40,000 kW

Installed units
2,100

Installed power
9.5 GW



- CO₂-fertilizing in greenhouses



200 – 6,000 kW

1,800

3.2 GW



Mobile



- On- and offshore vessels
- Cruise liners
- Freight vessels



500 – 40,000 kW

550

1.5 GW



- Yachts
- Inland water vessels
- Ships



200 – 9,000 kW

850

600 MW



- Locomotives
- Track construction machines
- Railcars



200 – 5,000 kW

1,100

1,200 MW



- Construction machines
- Commercial machines
- Trucks & buses
- Agricultural & forest machines



15 – 5,000 kW

More than 37,000

n.m.



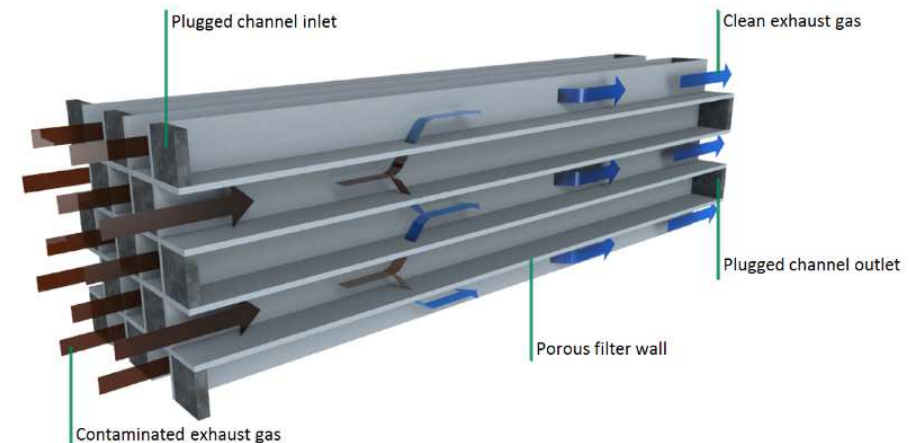
DIESEL PARTICULATE FILTER (DPF)

-97%
BC

black carbon

- 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)

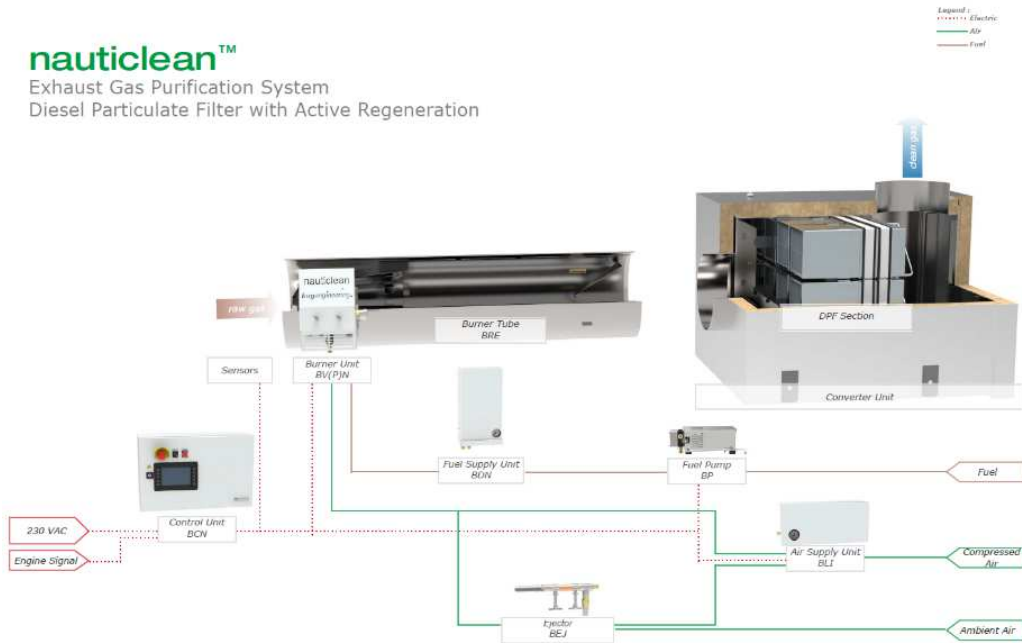
- Fuel and oil quality important!



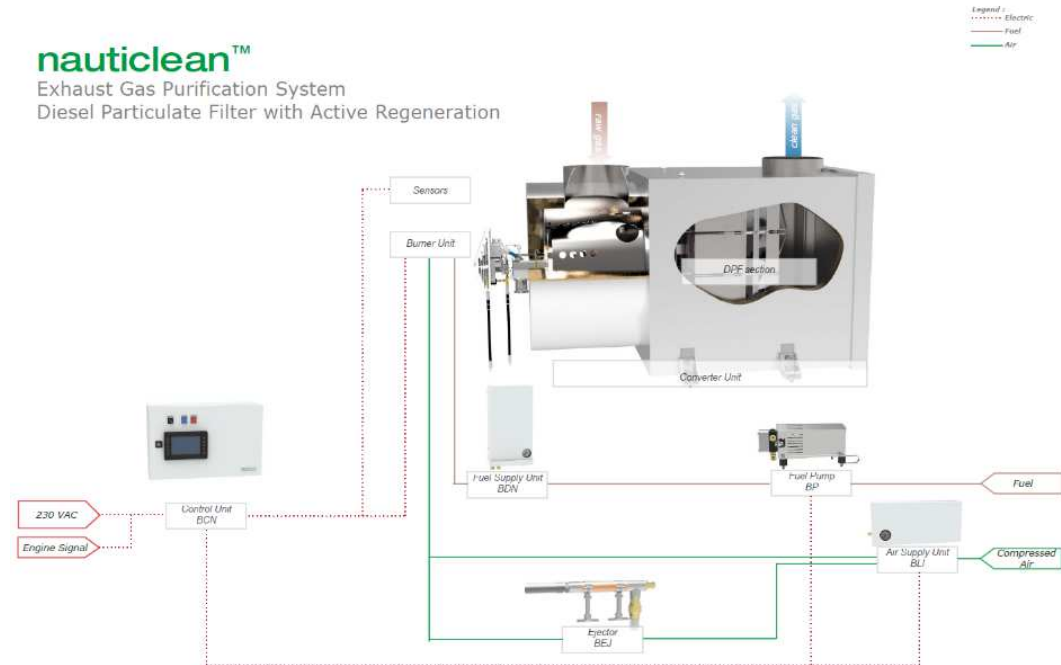
wall flow filter principle

MARINE DPF SYSTEMS

nauticlean™
Exhaust Gas Purification System
Diesel Particulate Filter with Active Regeneration



nauticlean™
Exhaust Gas Purification System
Diesel Particulate Filter with Active Regeneration



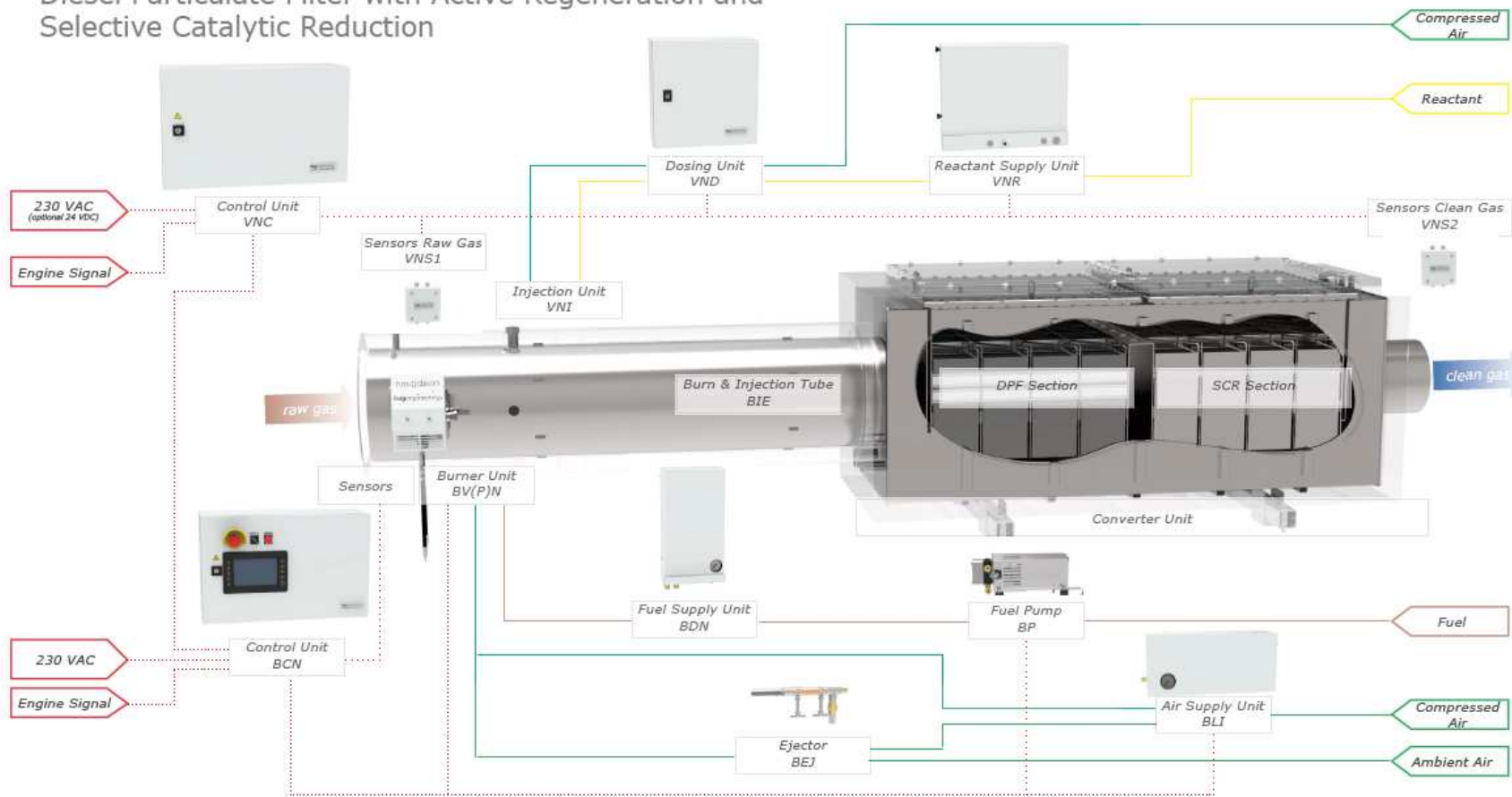
diesel burner for regeneration (burner pipe or chamber)
reactor housing with filter cassettes (various aspect ratios)
➔ modular setup for flexible arrangement

Yacht/inland water vessel DPF+SCR

nauticlean™

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

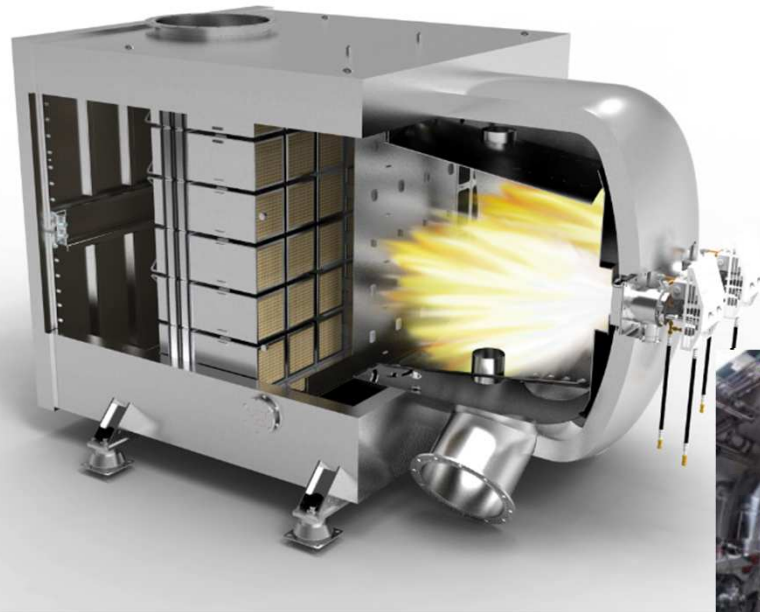
Legend:
..... Electric
..... Reactant
..... Air
..... Fuel



-80%
NO_x

-97%
BC

MARINE DPF EXPERIENCE



MOTIVATION



Clean decks and upholstery
«no visible black carbon»

REGULATION IN SWITZERLAND



PN (particle number) limit of 250'000 #/cm³ 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

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

Measurement analytics:

PN – condensation particle counter (CPC)

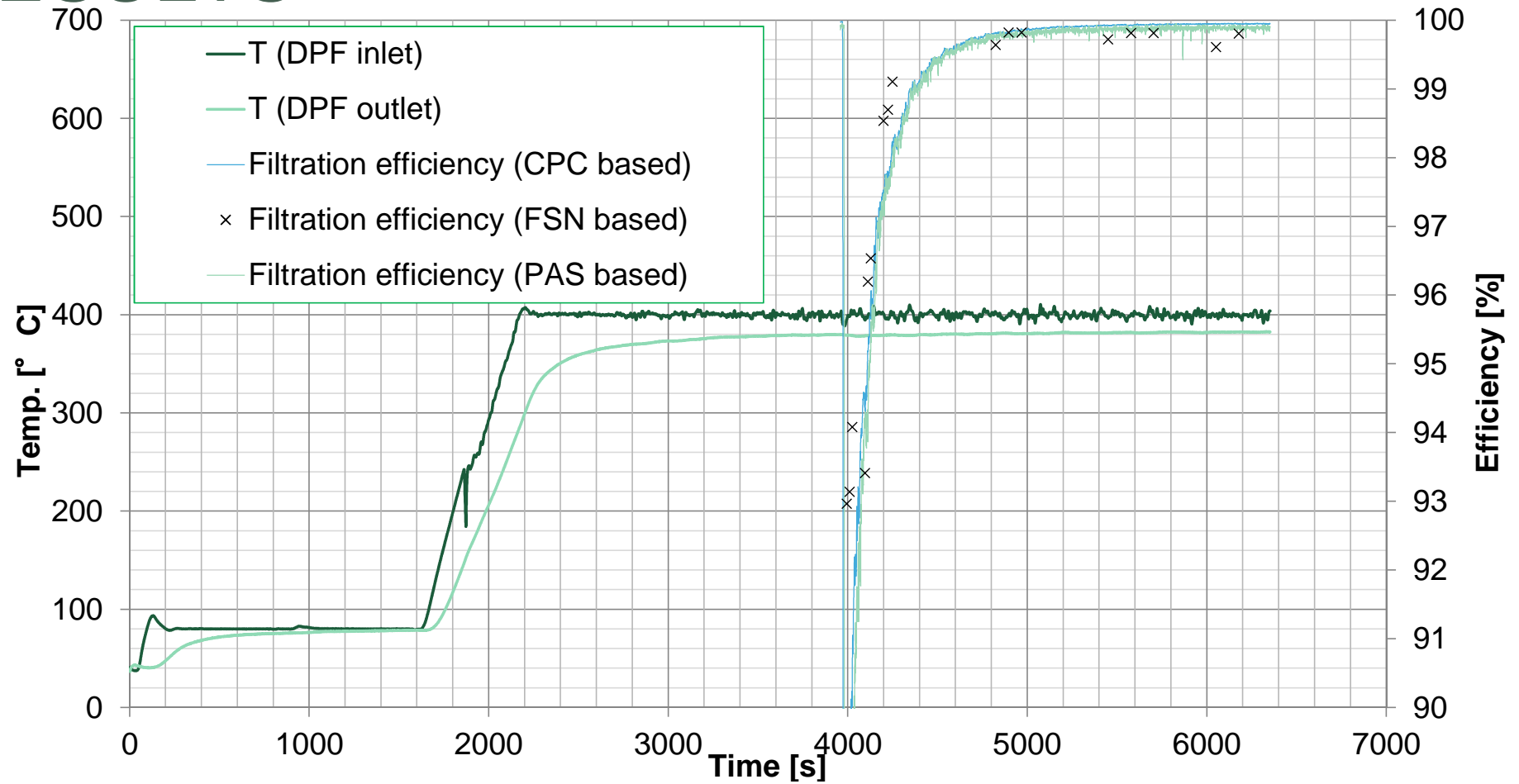
PM (soot) – AVL micro soot sensor (MSS)

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

RESULTS



➔ >97% abatement based on all measurements after <200 s

FIELD MONITORING

100's of marine DPF installations available, but no PM, PN or BC regulation
→ 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

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»

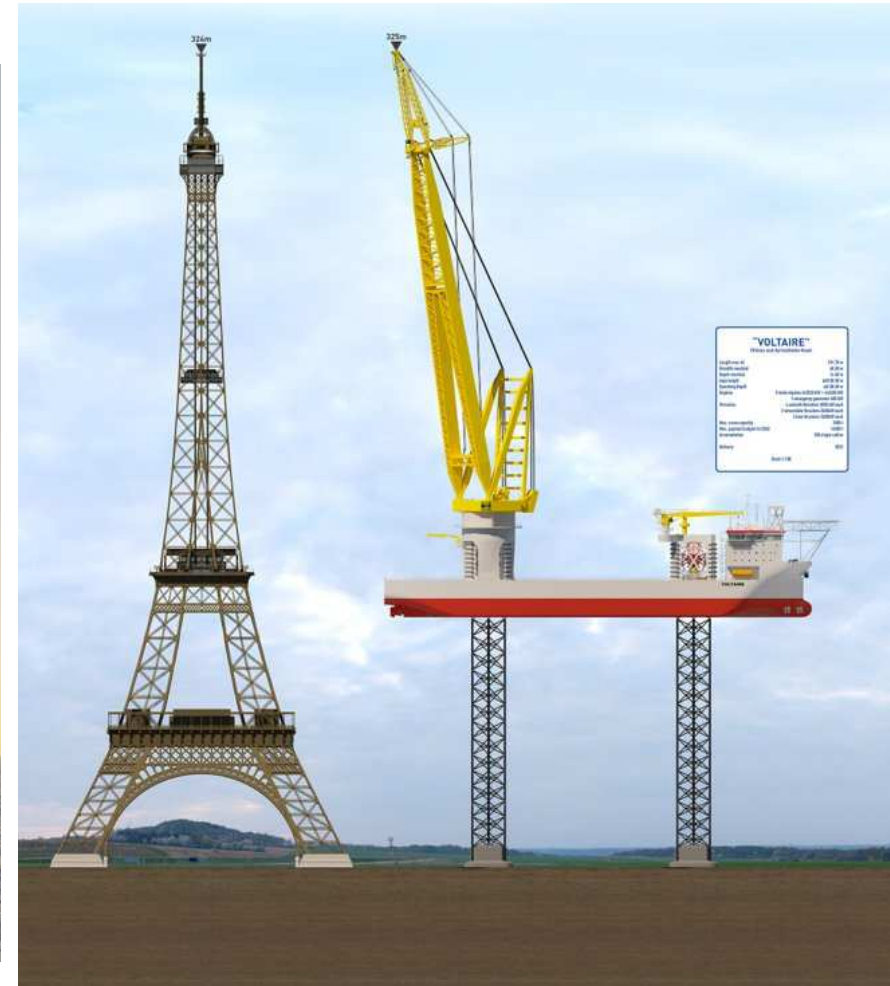
→ DPF spreading to medium speed diesel engine applications

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



"VOLTARE"	
Length	210 m
Breadth	30 m
Height	120 m
Weight	10,000 t
Capacity	10,000 t
Speed	10 knots
Max. Power	10,000 kW
Max. Torque	10,000 kNm
Max. RPM	1000
Max. Fuel	10,000 t
Max. Oil	10,000 t

K. Christianen, Y. Loulidi, D. Peitz, L. Mattheeuws, T. Berckmoes

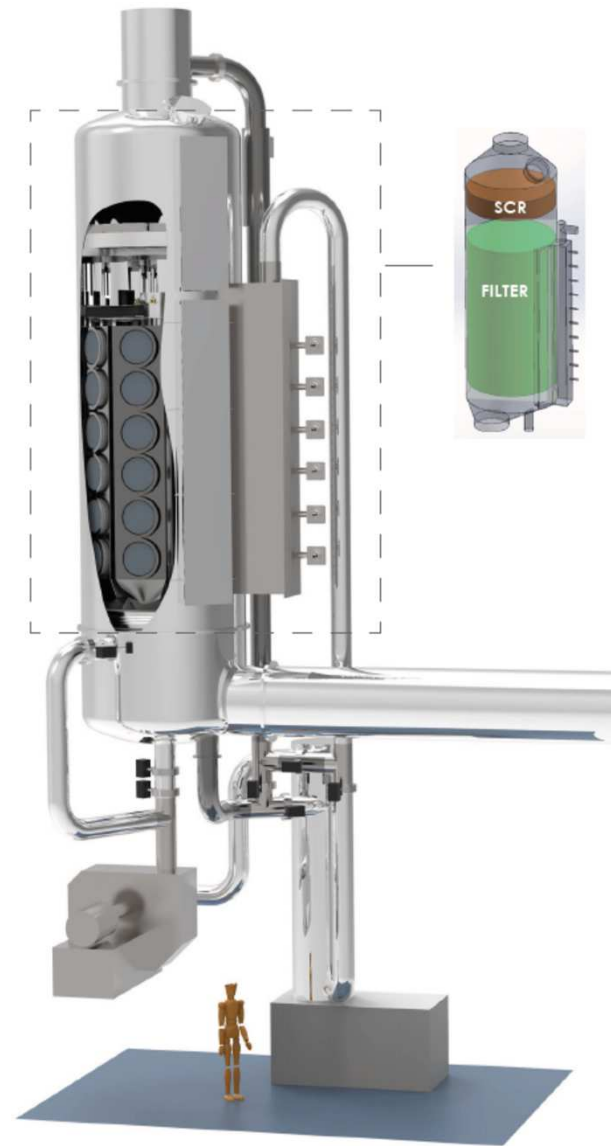
Integration and Matching of Diesel Particulate Filters for ABC Medium-Speed Engines, CIMAC Congress 2019, paper no. 361.

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



Confidential

engineering.
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-80%
NO_x

-97%
BC

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Thank you
for your attention.

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