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Diesel particulate filters in marine use – performance evaluation after three years of service

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March 24.th 2022

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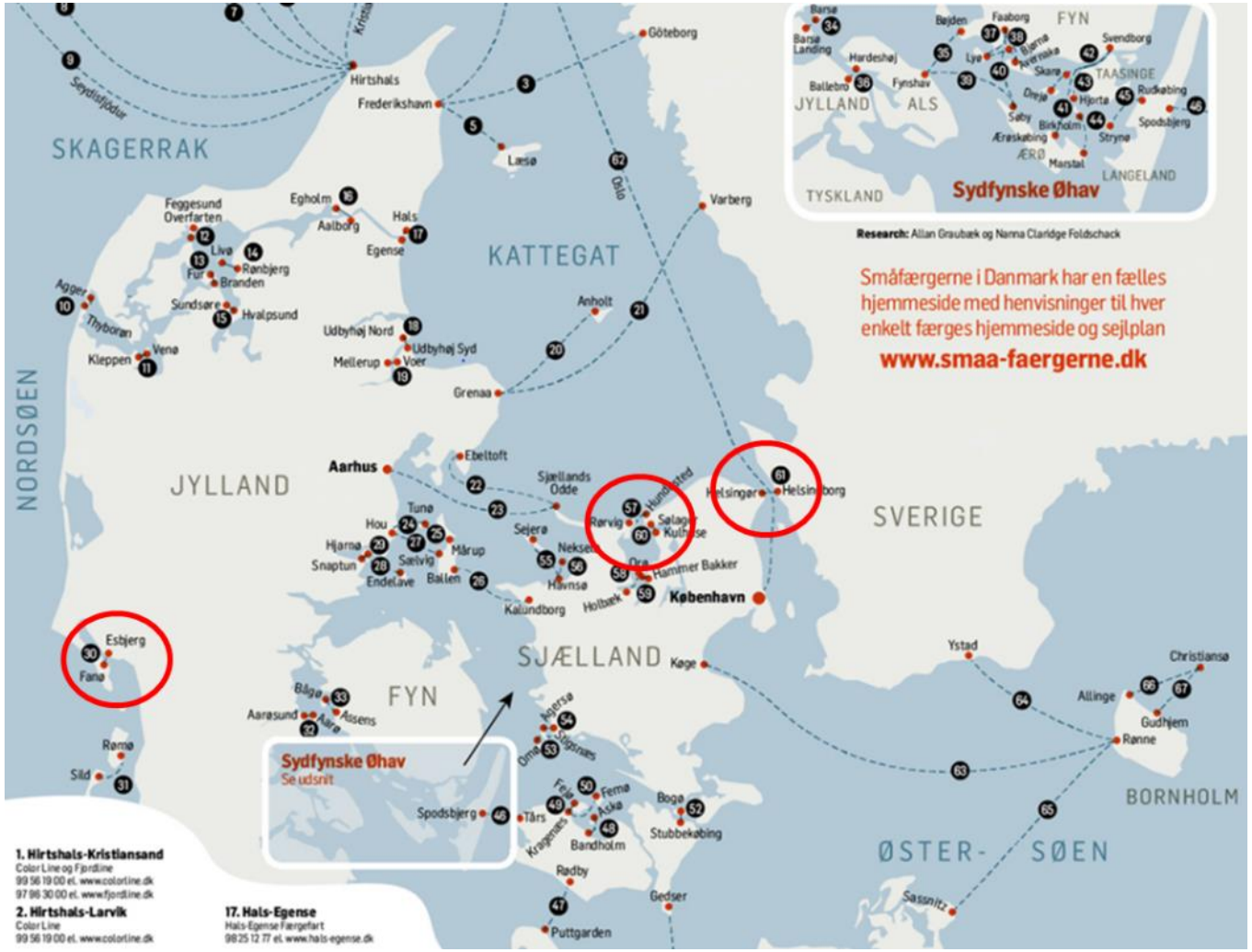
Agenda

- Introduction to the retrofit project
- Performance evaluation of DPF retrofit installations on M/F Isefjord
- Presentation of a sulfur tolerant retrofit aftertreatment solution for HD marine engines with SCR and DPF



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Project title: Marine aftertreatment solutions for vessels operating in coastal waters

- Project purpose is to develop, implement and demonstrate emission aftertreatment technology for marine vessels in coastal waters in Denmark
- Technology suppliers gain competence to enter marine retrofit projects
- Funded by Environmental Technology Development and Demonstration Program (MUDP) under Ministry of Environment of Denmark

EXILATOR

PUREFI DIESEL EXHAUST FILTER TECHNOLOGIES

Amminex Solid Technology - Clean Air

World Marine Offshore

H/R

SUNDBUSSERNE

AARHUS UNIVERSITY

DanishShipping

Danish Maritime

Transportens Innovationsnetværk

Medfinansieres af Uddannelses- og Forskningsministeriet

Ministry of Environment and Food of Denmark
Environmental Protection Agency

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Project title: Marine aftertreatment solutions for vessels operating in coastal waters

- Demo 1: M/F Isefjord, RO-RO ferry. Engines retrofitted with DPF in 2018 by Exilator ApS
- Demo 2: World Marine Offshore. Planned retrofit with DPF and SCR on main engines by Purefi A/S
- Demo 3: M/S Pernille, passenger ferry built 1981. Demonstration cancelled in 2020

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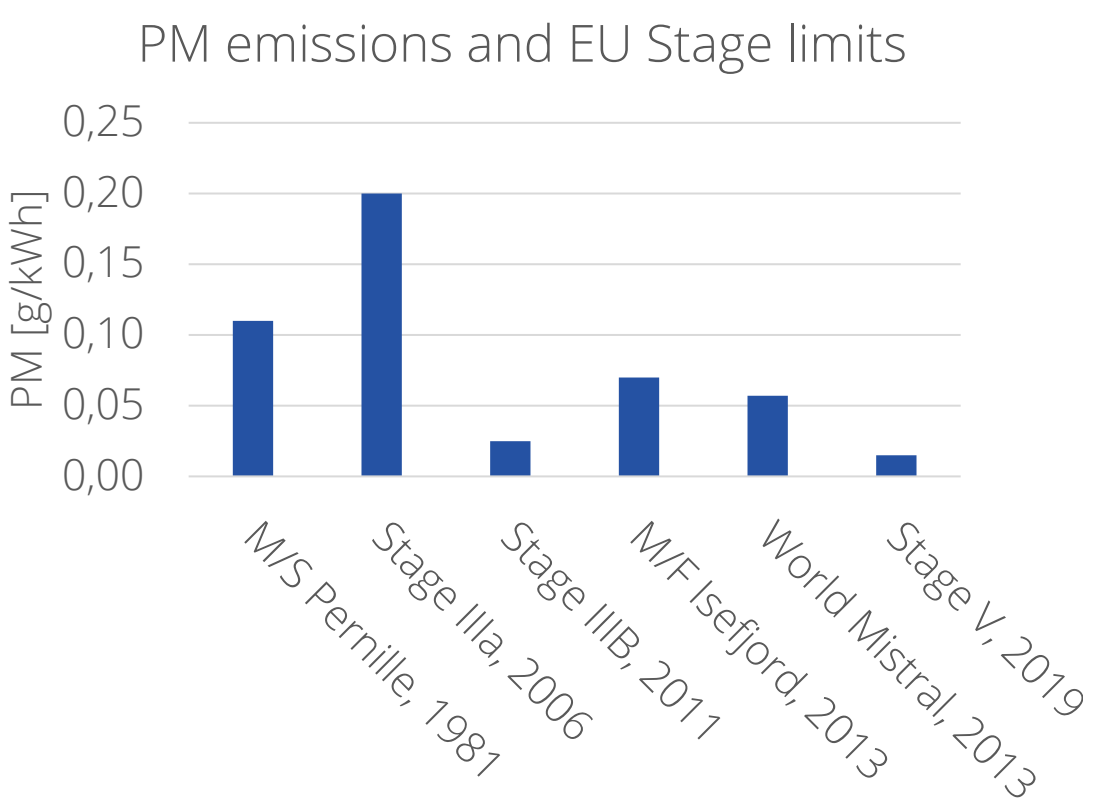
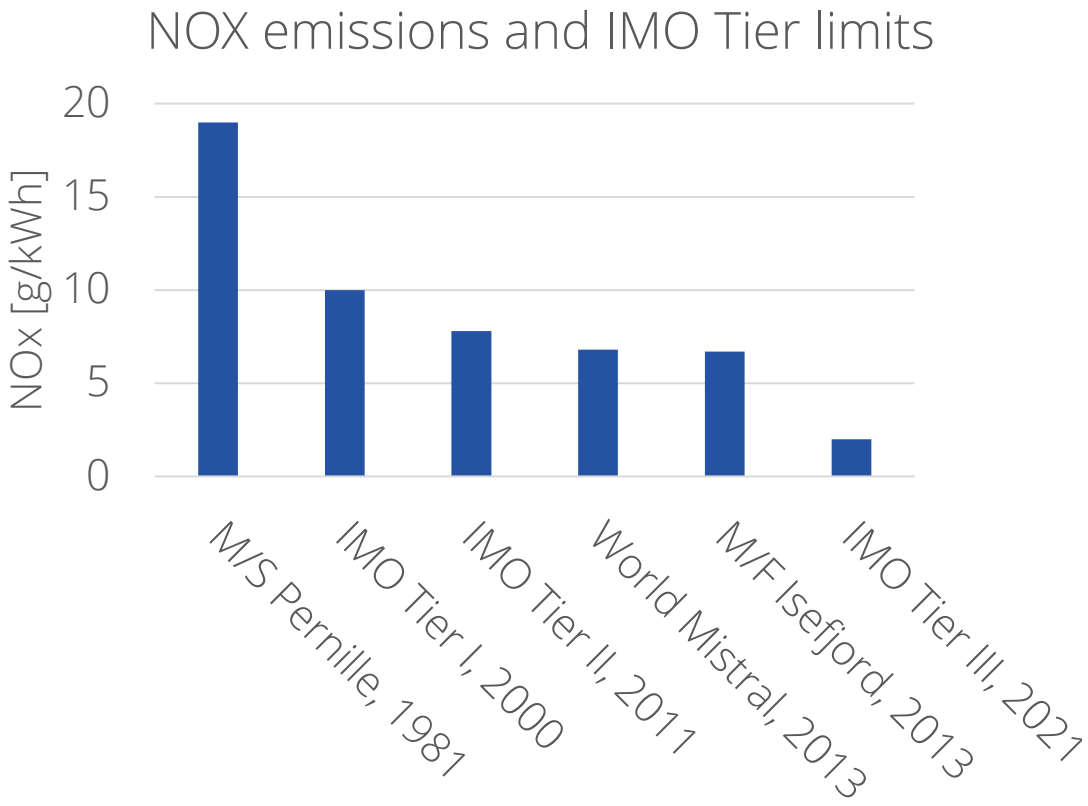
Specific emissions of vessels before retrofit





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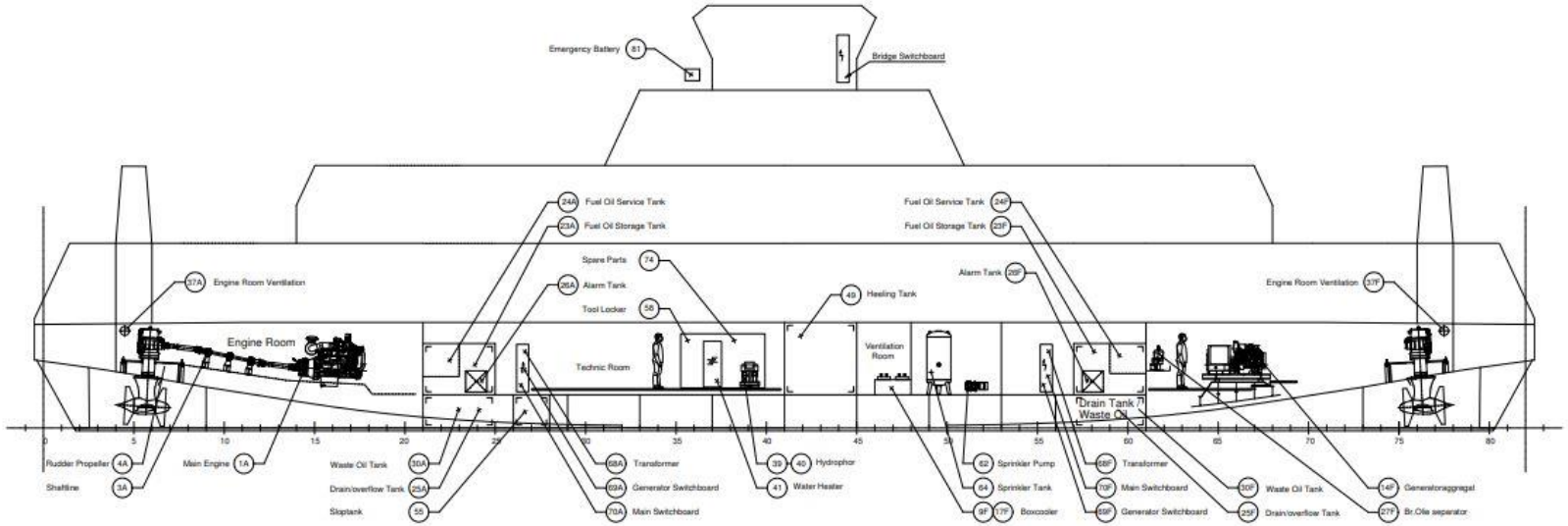
Installation on M/F Isefjord (built 2013)

- All engines retrofitted with catalytic DPF
- Main engine DPF regenerate passively in operation
- Aux engine DPFs have scheduled periodic regeneration



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Engines	Model	Rating	Emission
2x Propulsion	Cummins QSK-19M	373 kW MCR	IMO Tier II
2x Aux power	Cummins 6CT8.3-D(M)	122 kW Prime	IMO Tier II

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Instrumentation for measuring particulate reductions on M/F Isefjord

Instrument		Principle
TSI NanoScan	PN, PSD	Scanning mobility particle sizer
DustTrak DRX	PM	Laser scattering
Pegasor Mi3	PM (PN)	Diffusion Charge (variable dilution)
Testo MD19-3E	Dilution	Rotation Disc thermodiluter
Catalytic Instruments CS015	Volatile elimination	Catalytic stripper
Testo 350 Maritime	NO, NO2, CO, CO2, SO2, O2	Electrochemical (CO2 with NDIR)

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Instrumentation for onboard PM/PN mesaurement

NanoScan SMPS
PSD 10-420 nm

Catalytic Stripper
350°C

Rotating disc diluter
150°C

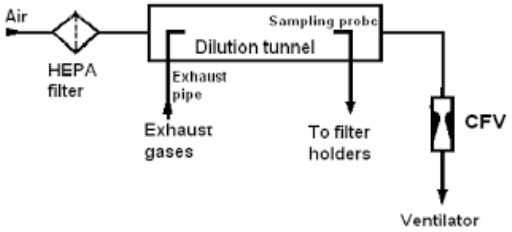
DustTrak
PM1

Exhaust gas

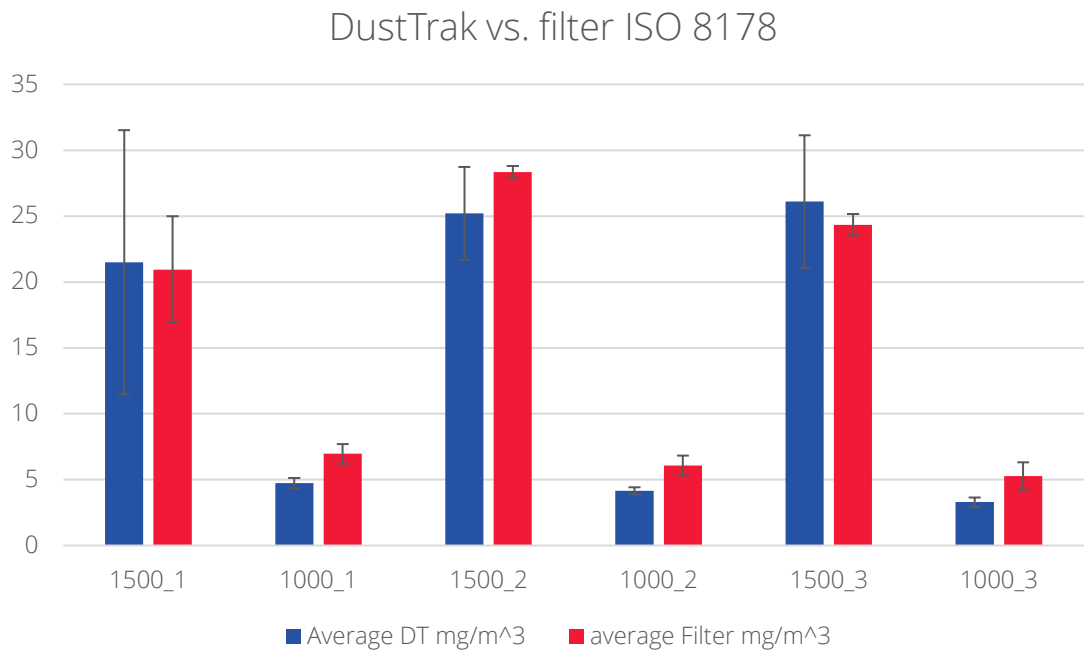
PM – *Pegasor Mi3*

NOx, NH3, CO
CO2, THC

PM – gravimetric sampling
ISO 8178



Reference PM measurements with DustTrak and gravimetric sampling with dilution tunnel (ISO 8178)



- DustTrak DRX optical measurements correlate well with gravimetric measurements
- Gravimetric measurements are not possible after DPF – DustTrak and other instruments are being used for measuring PM/PN to determine filter efficiency

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Particulate number (PN) reductions

Year	Time in operation	Engine	DPF efficiency
2018	8 months	Main engine Aux. engine	99.6 % of PN 99.8 % of PN
2020	34 months	Main engine	97.3 % of PN

- Efficiency as expected for closed wall DPF in first measurement
- Second measurement indicates possible leakage in casing sealings, likely after DPF monoliths have been removed and reinstalled after ash removal
- Exhaust gas leakage through bypass valve has also been observed

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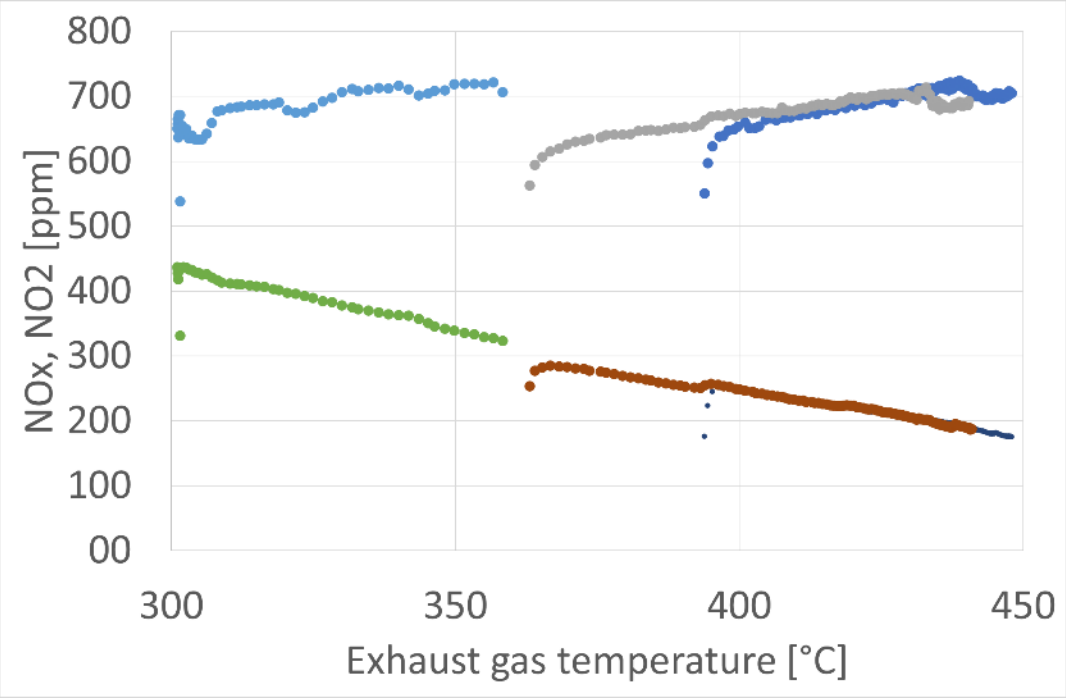
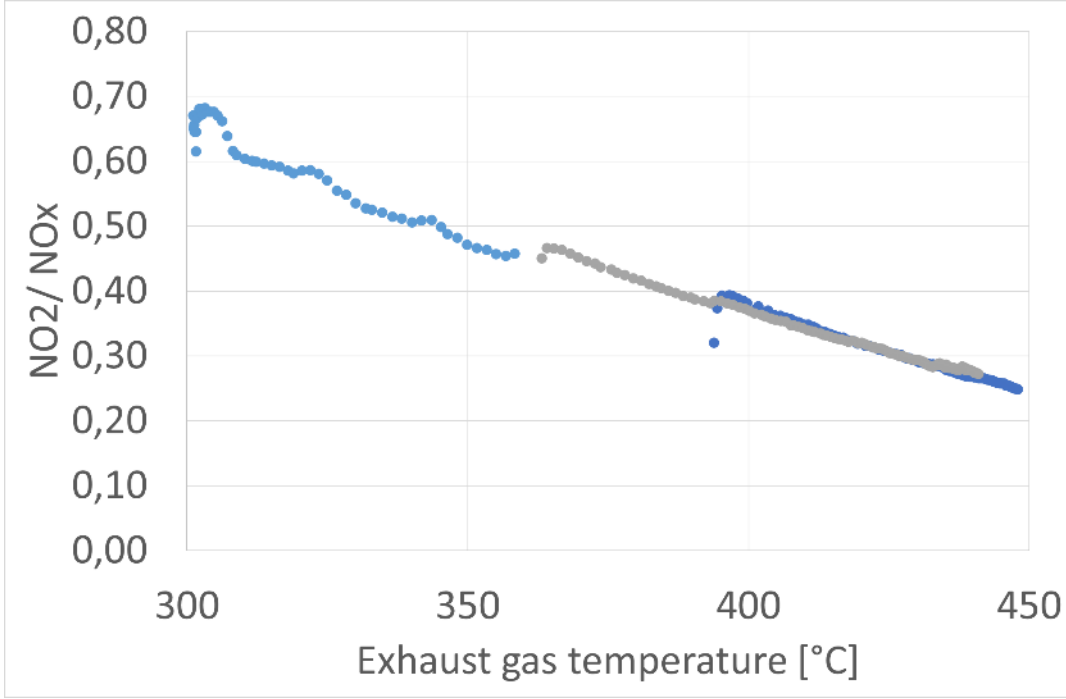
Catalytic conversion of NO to NO_2 (measured after 34 months)



NO_2 and NO_X concentrations after DPF



Ratio of NO_2 to NO_X after DPF

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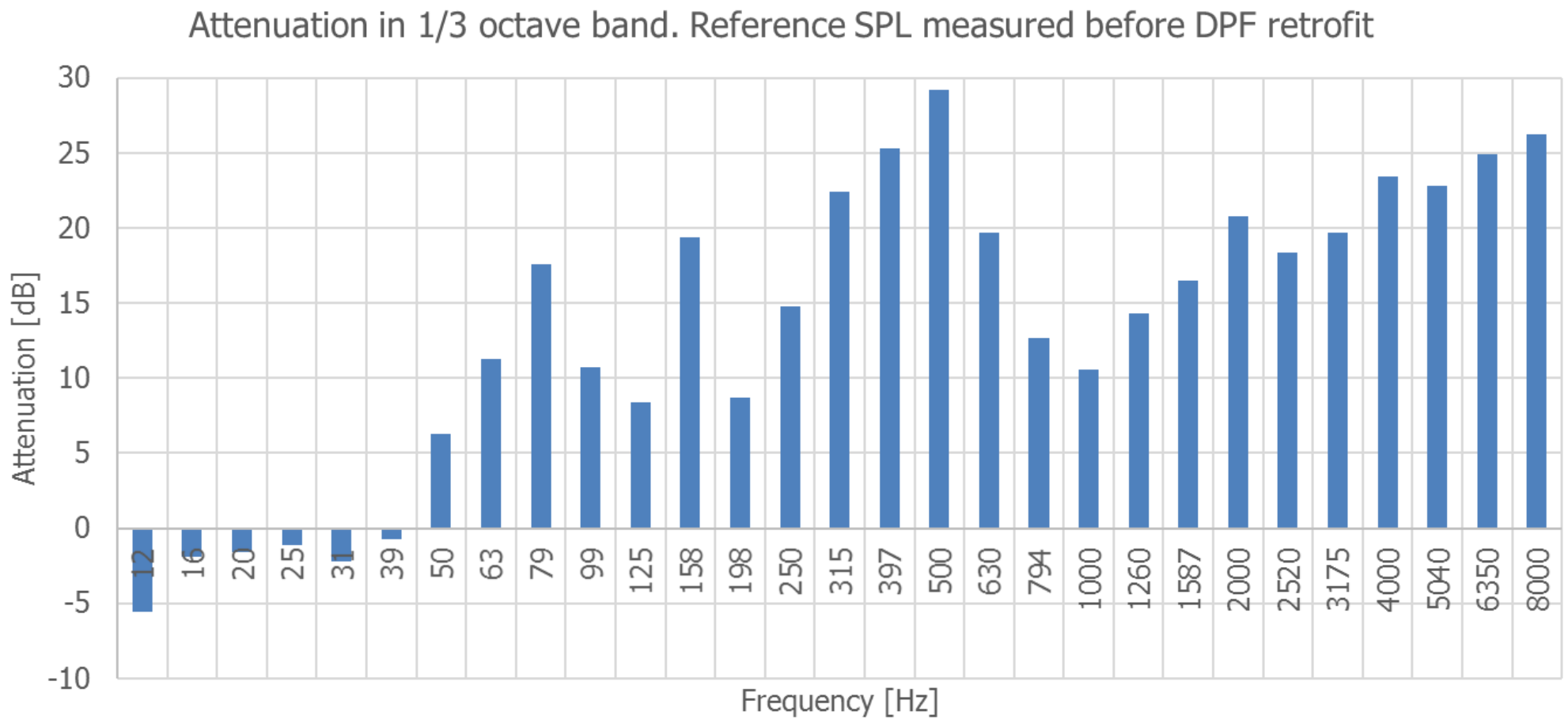
Noise reduction



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Installation on World Calima (build 2014)

- Demonstration vessel with trimaran design, no room for systems in engine bay
- Systems are mounted on top of ship
- Target is IMO Tier III (NOx), Stage V (PM/PN)

Engines	Model	Rating	Emission
4x Propulsion	Scania DI 16	605 kW MCR	IMO Tier II
2x Aux power		50 kW Prime	IMO Tier II

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Sulfur tolerant aftertreatment system with DPF and SCR

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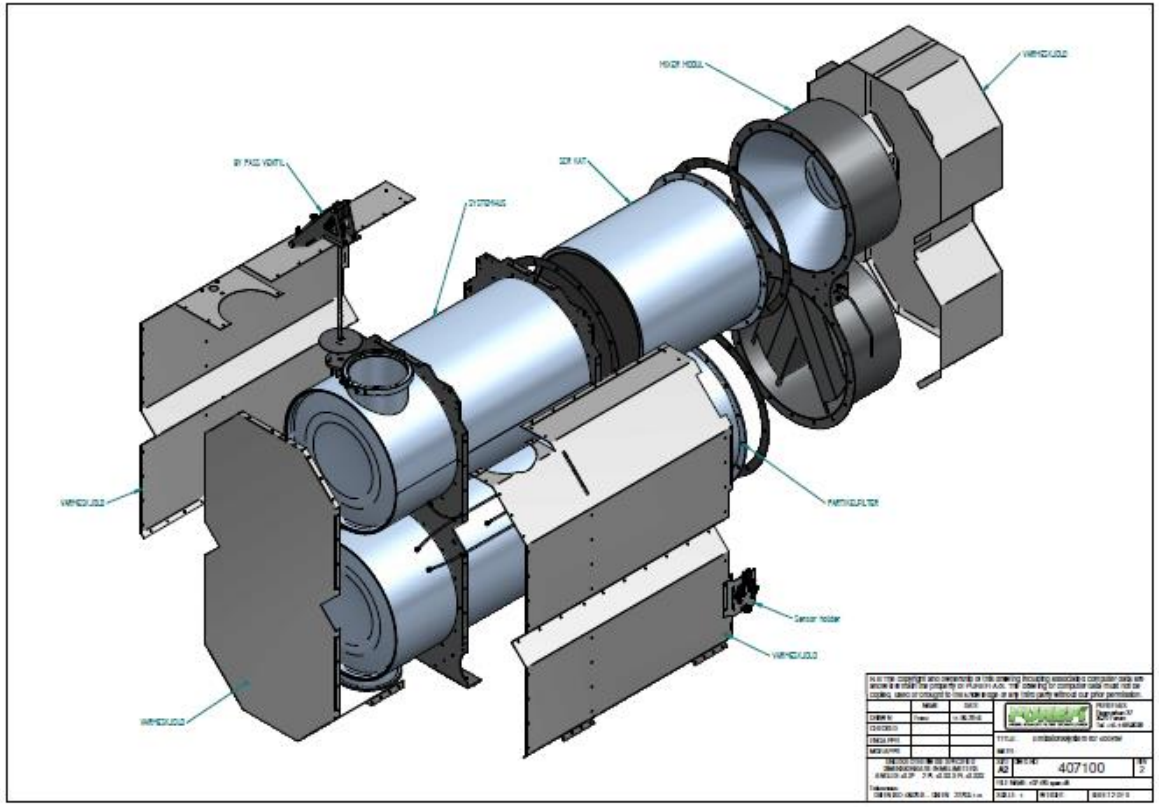

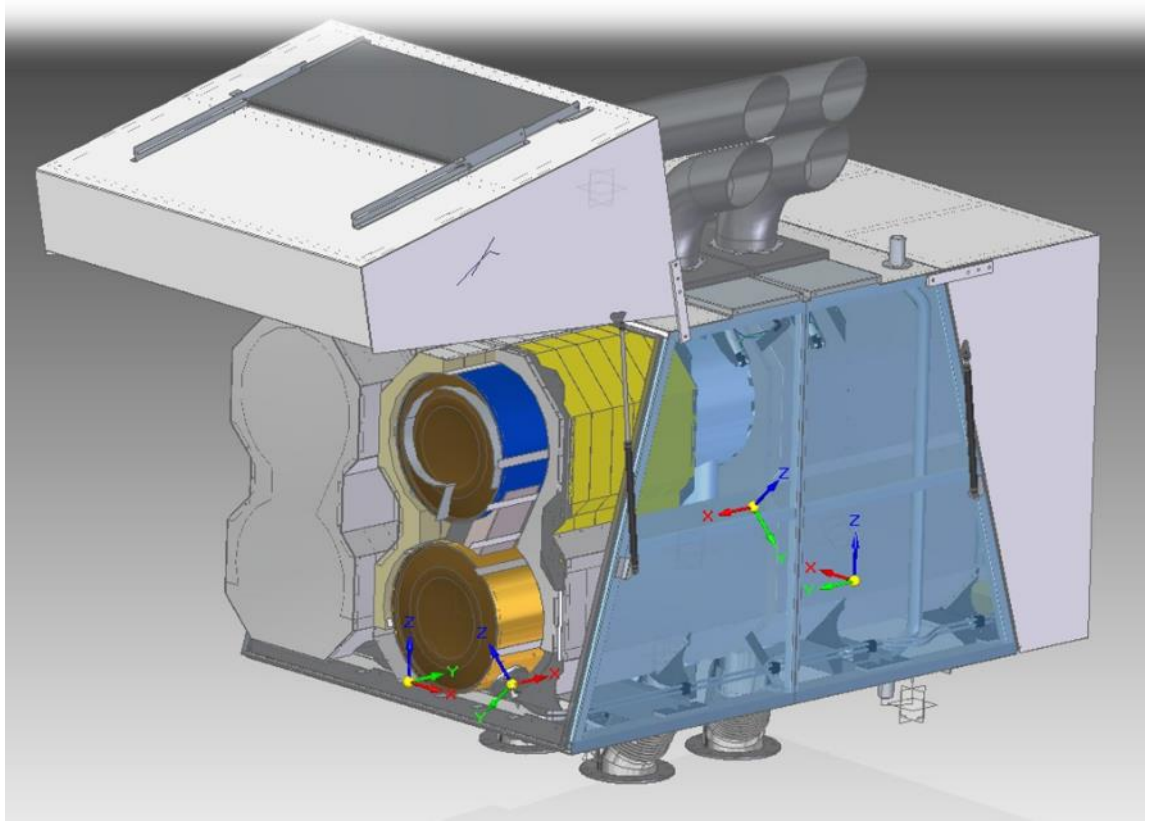

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Sulfur tolerant aftertreatment system with DPF and SCR

- Sulfur tolerant catalytic coating to at least 0.1% sulfur, limit in SECA zones
- Coatings provided by Umicore Automotive Catalysts
- DPF monoliths delivered by LiqTech Ceramics
- System integration, urea dosing and system control/monitoring by Purefi
- Integrated automatic bypass valve for safe operation at sea

umicore
Automotive Catalysts

LIQTECH

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