

Selective Catalytic Reduction

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DEC - Diesel Emission Control

- Comparison land / ship sources
- NOx regulations
- The SCR system
- SCR development review
- Costs



DEC SCR Converter™ system



Comparison land-based versus marine sources



Paper mill

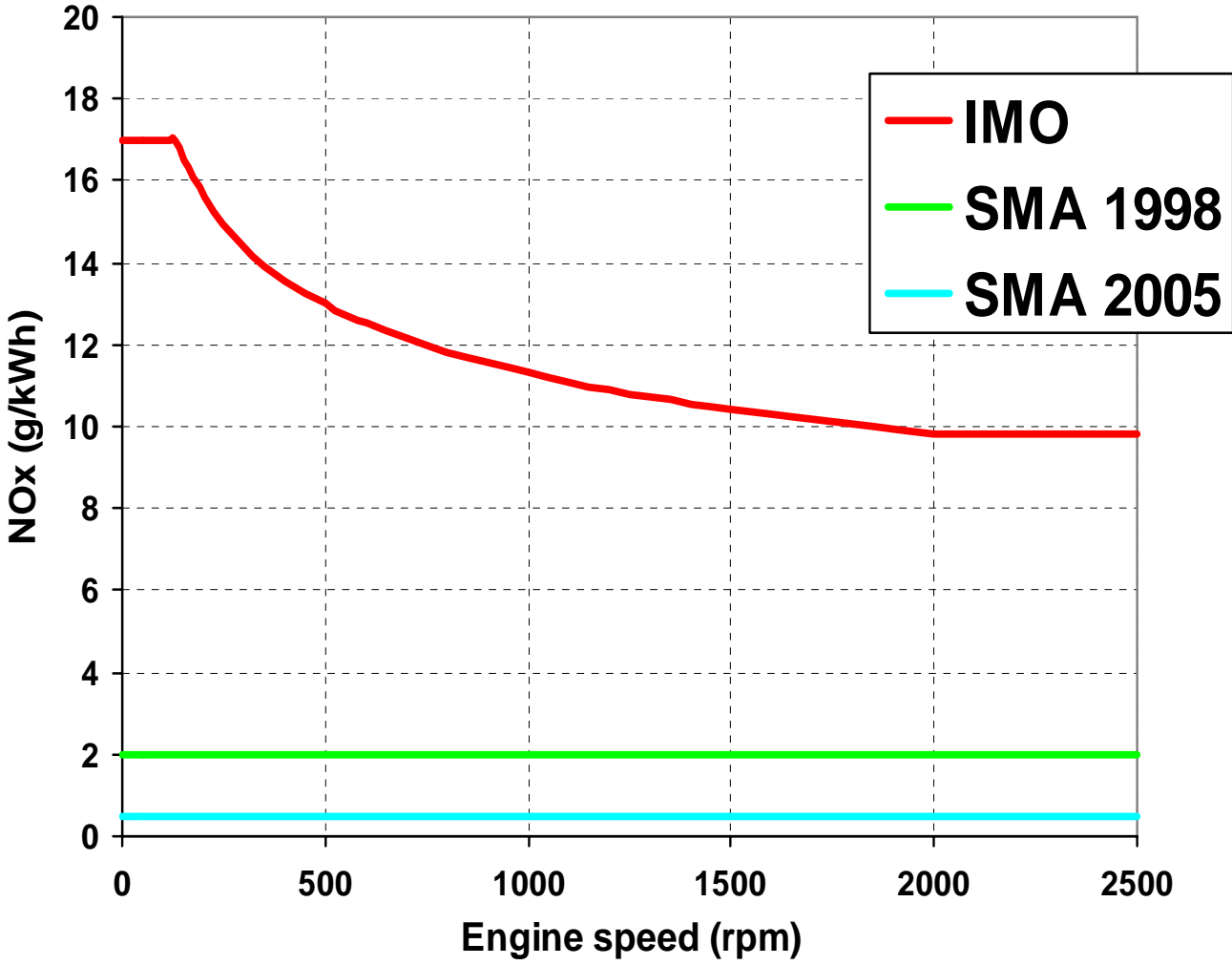
- Fuel cons.: 160 000 ton oe / year
- Emission to air: 570 ton NOx / year
- 3.5 kg NOx / ton fuel



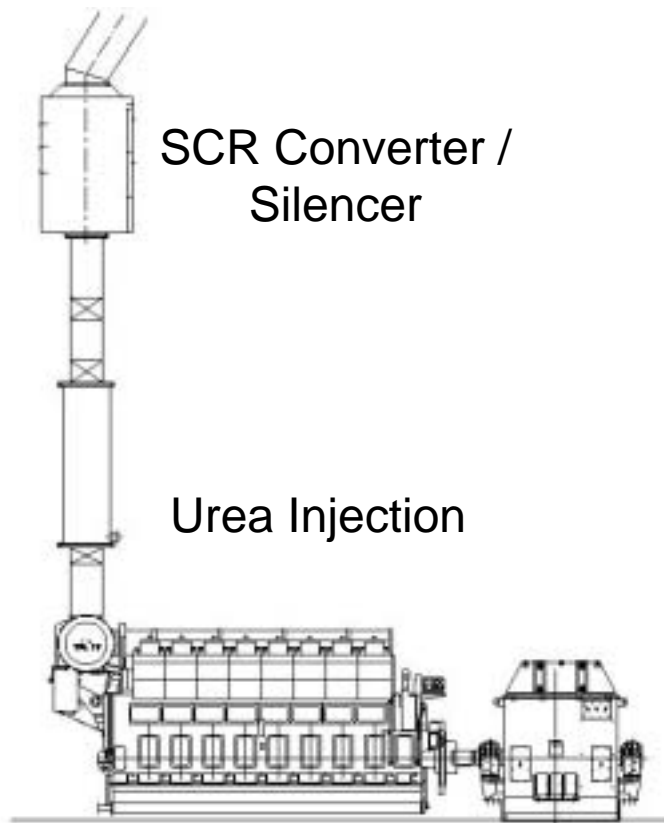
Paper carrier

- Fuel cons.: 15 000 ton / year
- Emission to air: 1 500 ton NOx / year
- 100 kg NOx / ton fuel

Marine NOx regulations



SCR - Selective Catalytic Reduction



- NOx reduction up to 99%
- Also reduction of (HC)
- Can be combined with Oxidation catalyst for CO reduction
- After treatment – easily adopted to various diesel engine makes
- DEC has delivered SCR system to > 200 marine diesel engines on 48 ships

SCR Converter for 7.2 MW Main Engine



SCR Control Metering Units



Comparison land-based versus marine sources



Paper mill

- Fuel cons.: 160 000 ton oe / year
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Paper carrier

- Fuel cons.: 15 000 ton / year
- Emission to air: 1 500 ton NOx / year
- 100 kg NOx / ton fuel

Retrofit with SCR in 2004

- Emission to air: 75 ton NOx / year
- 5 kg NOx / ton fuel

Marine SCR - Development review

1992 – First marine SCR + OXI installation



Aurora of Helsingborg

- Urea / water solution introduced as NO_x reagent
- Accumulated operating hours > 80 000

Marine SCR - Development review

1996 – First installation for operation on marine HFO



IB Atle

- Today 35 ships with SCR designed for HFO

Marine SCR - Development review

1999 – First installations for large bore slow speed engines



S-ships, three new-buildings for Wagenborg

- Designed for < 2 g NO_x/kWh in 1999 (90% reduction)
- Up-graded for $< 0,5$ g NO_x /kWh in 2006 (98% reduction)

Marine SCR - Development review

2006 – Reference list with 36 new buildings and 13 retrofit



SCR is a well proven method to reduce ships NOx emissions

Costs for installation of SCR system as retrofit

Examples

Ship type	Ferry	Cargo
Investment cost SCR system installed	45 EUR / kW	77 EUR / kW
Operating cost Mainly urea	200 EUR / ton NOx	200 EUR / ton NOx
NOx reduction	2600 ton / y	1400 ton / y
Total cost 5 years write off	335 EUR / ton NOx	310 EUR / ton NOx
Total cost 10 years write off	268 EUR / ton NOx	255 EUR / ton NOx