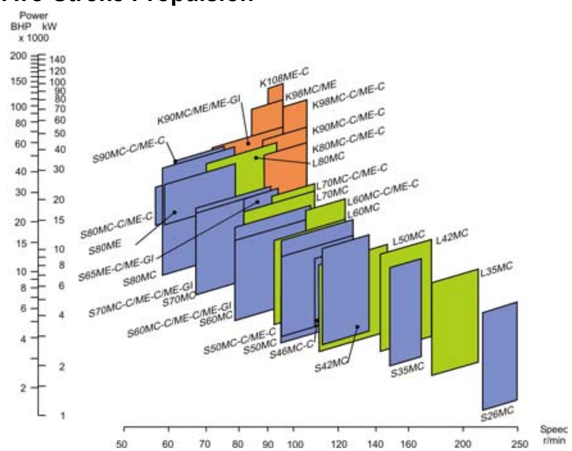
Faster Freight-Cleaner Air 2006
Long Beach, January 30-February 1.

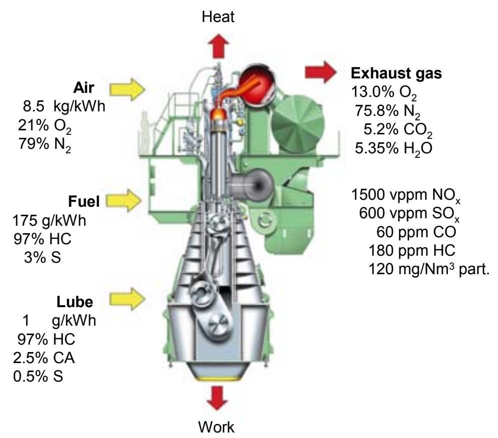
How engine manufacturers are meeting the challenge by refining their technologies for emission control.

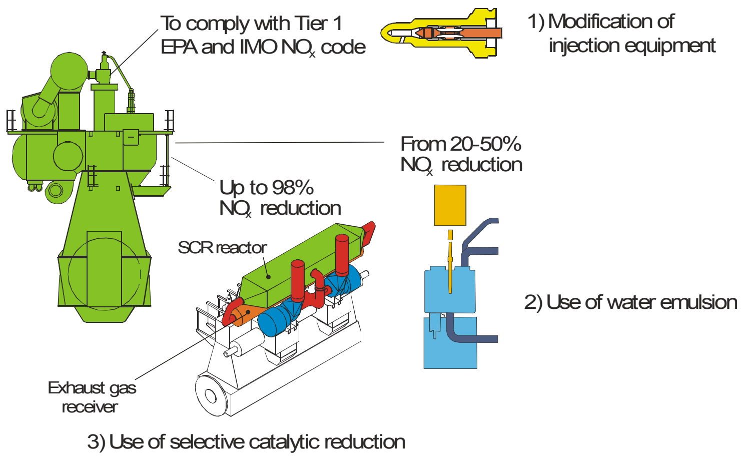
6S35MC and 10K98MC-C on Testbed

Marine Engine Programme 2006

Two-Stroke Propulsion

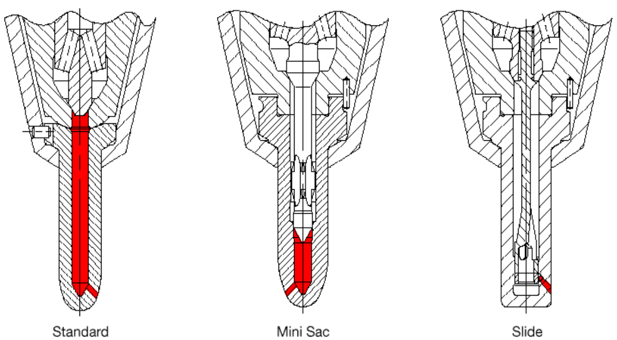






Slide Valve Design

Cross sections of fuel-valve nozzle tips



MAN B&W Diesel

Slide Valve Characteristics

Minimal sac volume – no 'dripping'

* Less HC and particulate emissions
* Less smoke formation
* Reduce fouling of gas ways and exhaust gas boiler
* Reduce fouling of piston topland and cylinder liner

Usually combined with low-NOx behavior

Easy to retrofit

MAN B&W Diesel

Measurements results from use of slide type fuel valves

Engine / Serial number	Hitachi Zosen MAN B&W main engine 8L60MC No. 3481, MCR 1250 kW				
	MAN B&W slide type fuel valves		MAN B&W previous design fuel valves		
Mode	Main engine	Main engine	Main engine base-line	Main engine base-line	Main engine base-line
Power set-point %	73	62	65.5	75	75
Date	2003-11-13	2003-11-13	2002-04-26	2003-04-17	1999-02-25
Time at start of mode	09:40	11:30	09:10	10:40-13.00	16:55
NO_x spec. emission corr. g/kWh	13.8	13.2	18.7	17.6	15.0
CO specific emission corr. g/kWh	0.47	0.71	0.26		0.31
TOC spec. emission corr. g/kWh	0.15	0.17	0.12		
CO_2 spec. emission g/kWh	578	584	585	577	562
SO_2 spec. emission g/kWh	7.2	7.2	6.4	7.2	9.3
PM specific emission corr. g/kWh	0.56	0.59		1.1	

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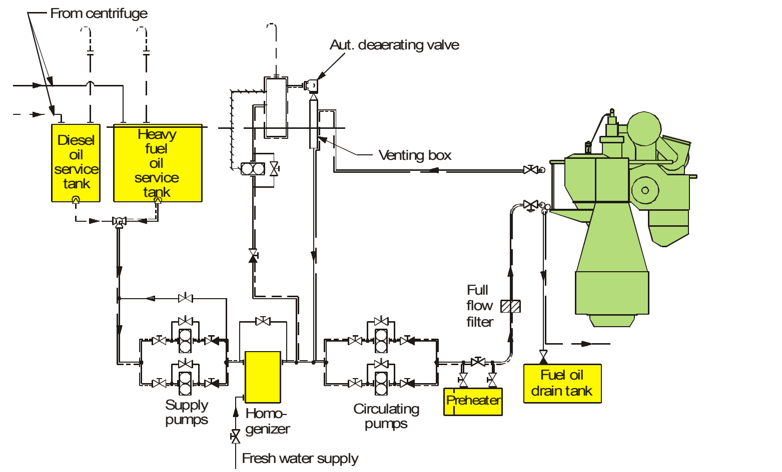
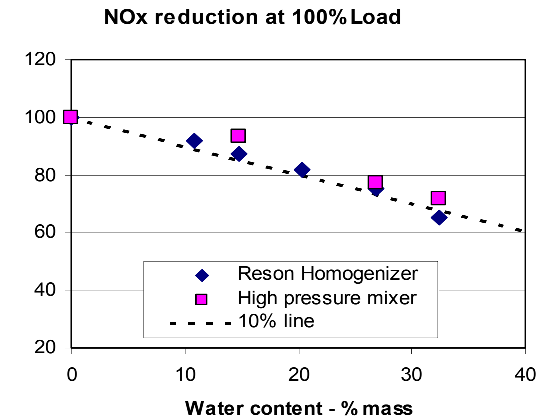
NOx Emission Control
Water Emulsion Fuel



MAN B&W Diesel



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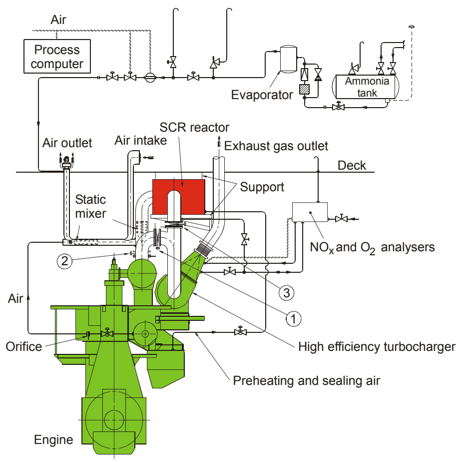
SCR system layout



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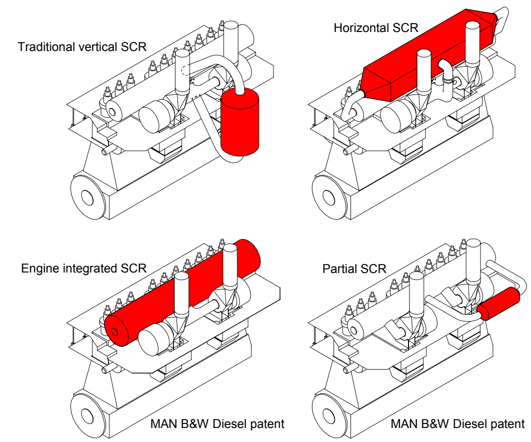
Alternative SCR configurations



M/V Delta Pride, 6S50MC, with selective catalytic reduction

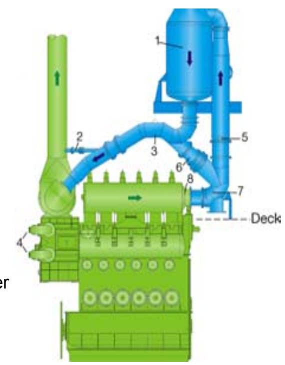
M/V Navion Dania with SCR catalytic reactor installed

On the M/V Navion Dania, urea is used for NOx reduction. The urea is stored in hull tanks

6S35MC, deNOx

6S35MC, deNOx

1. SCR reactor
2. Turbocharger bypass
3. Temperature sensor after SCR
4. Large motors for auxiliary blowers
5. Urea injector
6. SCR bypass
7. Temperature sensor before SCR
8. Additional flange in exhaust gas receiver



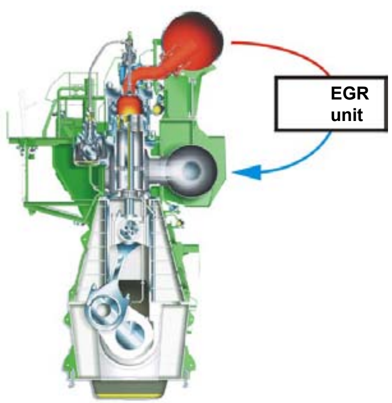
Engine performance data

	Prior to installation of SCR	*$deNO_x$ mode with injection of urea*
Engine load	**75.8%**	**77%**
Turbocharger rpm	**15,600**	**15,700**
T/C inlet temperature	**440 ° C**	**440 ° C**
Scavenge air pressure	**2.02 barg**	**2.10 barg**
NO_x emission	**1100 ppm***	**132 ppm* (<2 g/kWh)**
Urea consumption	**-**	**62 l/h**

* Measured during SCR test trial

Schematic Design of EGR system

EGR influence on NO_x formation



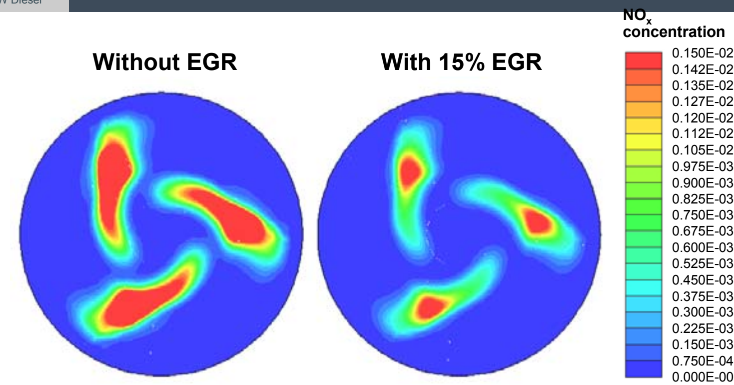
Re-circulation of exhaust gas lowers O_2 in scavenge air

Low O_2 in scavenge air gives low combustion temperatures

Low combustion temperatures give low NO_x

Influence on reliability and safety: Field test

NO_x Formation



4T50ME-X combustion chamber

NO_x concentration in a horizontal incision in level with the atomizer holes

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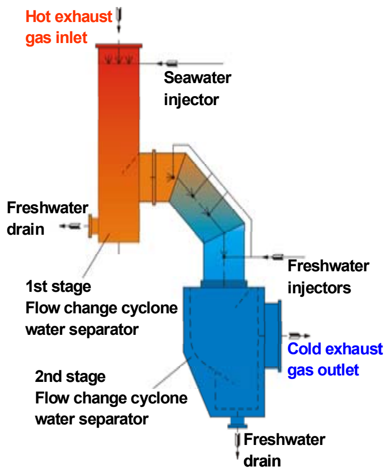
NOx Emission Control
Exhaust Gas Recirculation System



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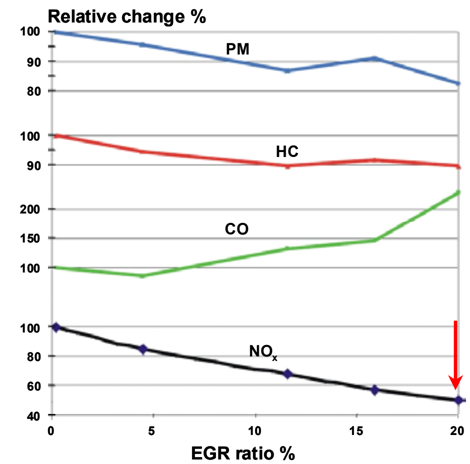
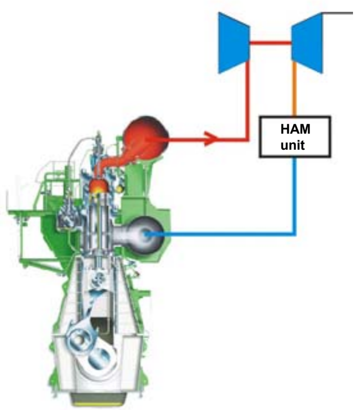
NOx Emission Control
EGR Emission Parameters



Emission Parameters at 75% Load at Various EGR Ratios

Principle Design of HAM system (Humid Air Motor)

HAM influence on NO_x formation



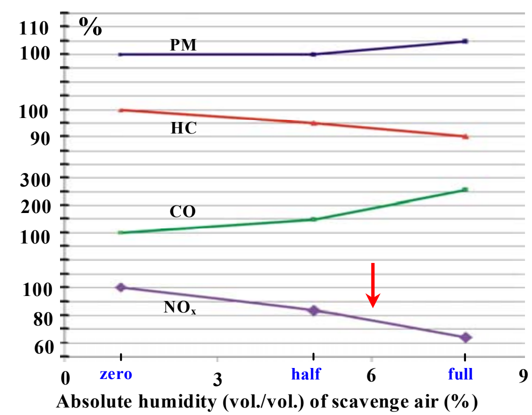
Humidification of scavenge air increases heat capacity and lower the O_2 content

High heat capacity and low O_2 in scavenge air give low combustion temperatures

Low combustion temperatures give low NO_x

Influence on reliability and safety: Field test

NOx Emission Control SAM Emission Parameters



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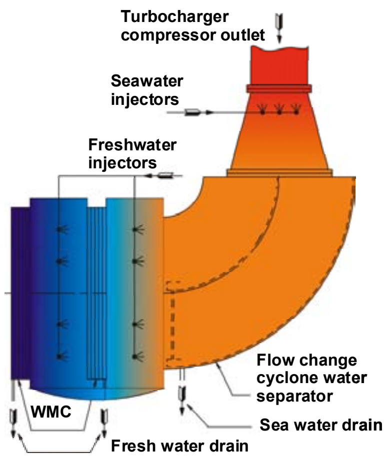
NOx Emission Control
Scavenging Air Moistening System



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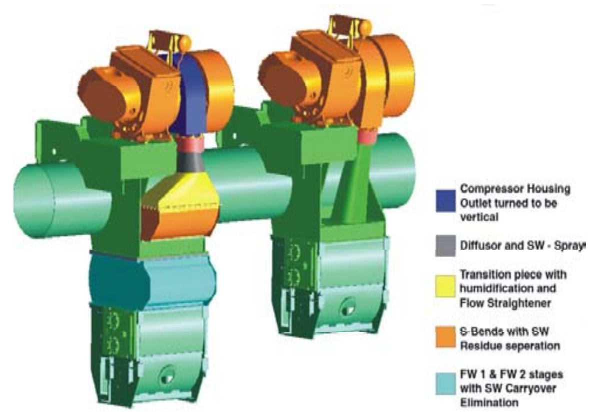
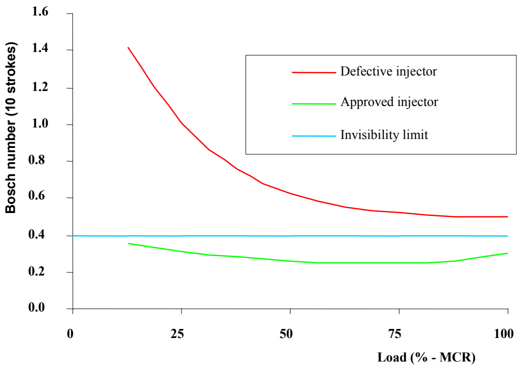
NOx Emission Control, SAM
Application and Conventional Cooler



NOx Emission Control
SAM Application

7S60MC Soot-Emission



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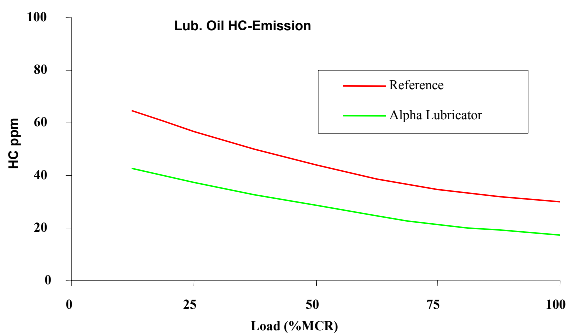
Lube oil related HC-Emission



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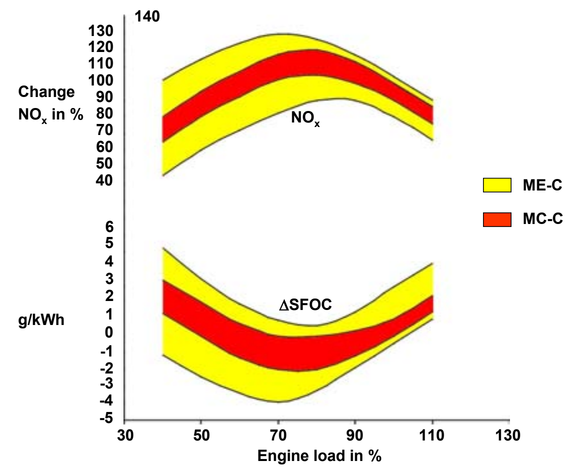
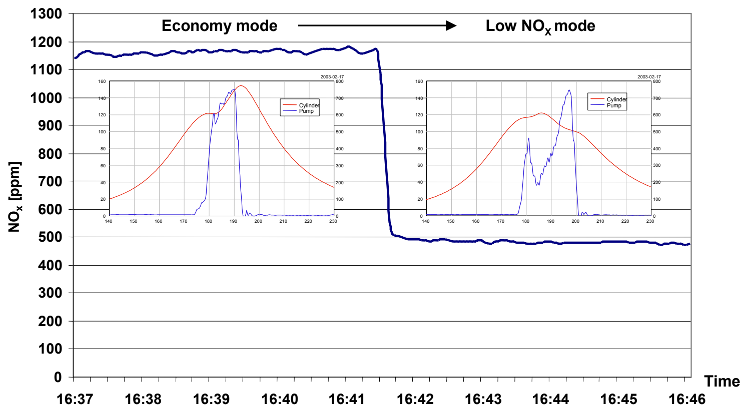
Flexibility of the ME Concept



NO_x and economy mode ME engine



CO_2 Emission

Plant efficiency: Good potential for CO_2 reduction

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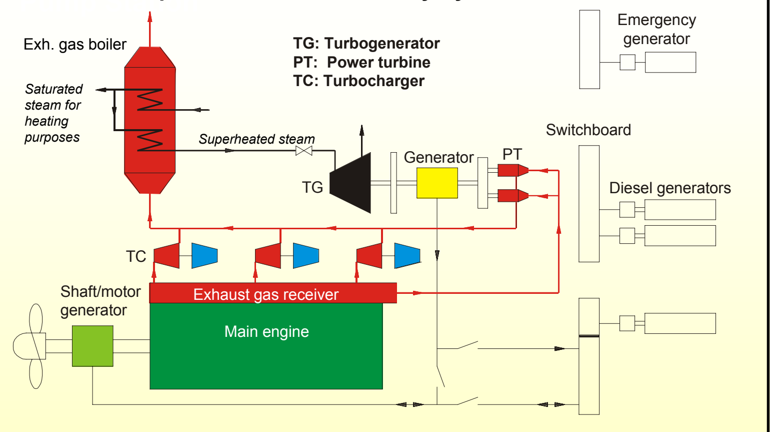
Power Concept for a Thermo Efficiency System



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Conclusion and Tier 2 – Considerations

1. From 1997 to 2004 has the averaged NOx for a two-stroke engine been reduced with approx. 20%
2. Fuel consumption (and CO2) has increased with approx. 2% (the tolerance increased from 3 to 5%)
3. CO varies with engine type and fuel-nozzle lay out, but the value is generally less than 1.5 g/kWh
4. Slide valves have been introduced to improve cylinder and gas- way conditions and to lower the HC emission. HC is generally less than 1.0 g/kWh and usually lower for heavy fuel than diesel oil

Conclusion and Tier 2 – Considerations

5. The electronic engine concept the Economy mode, is complying with the IMO NOx regulation at best fuel consumption. Emission mode with NOx around 13 g/kWh (or 20% lower than the IMO limit). But with a penalty in fuel consumption. Other modes will come.

6. SAM/HAM/EGR/FWE or FWI are new technologies investigated for reducing NOx further. These methods may bring the NOx below 10 g/kWh, but extensive evaluation and maturing on-board is necessary

7. Low-NOx operation should be restricted to certain areas (similar to SECA areas) or to a certain distance from the coast (US EPA has defined 175 nautical miles in Tier 1.)

8. Future technologies should focus on reducing emission in coastal areas, preferably by market based instruments (voluntary with incentives)