Workshop „Abgasnachbehandlung“ VDR + Mariko

TECHNIK

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- What is NOx?
- Development of Emission Limits
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Introduction of ERC

- Established in 1993
- Headquarter Buchholz
- Production sites Wahlstedt and Buchholz
- Family owned company
- > 125 employees
- > 45 Mill € revenue
- > 700 NOx reduction systems (SNCR + SCR) installed globally
- Supply of additives for fuel incl. bunker oil
  - Reduced PM emission
  - SO_2/SO_3 inhibitor
  - Combustion improvement

What is NOx?

- NO_x is a generic term for mono-nitrogen oxides (NO and NO_2) produced during combustion, especially at high temperatures
- The NO_x fraction of the exhaust gas of diesel engine usually consists of 95 % NO and 5 % NO_2
- The three primary sources of NO_x in combustion processes are:
  - Thermal NO_x
  - Fuel NO_x
  - Prompt NO_x

What is NOx?

- Thermal NO_x formation is recognized as the most relevant source
- Fuel NO_x tends to dominate during the combustion of fuels
- The contribution of prompt NO_x is normally considered negligible
- Thermal NO_x refers to NO_x formed through high temperature oxidation of the diatomic nitrogen found in combustion air
- The formation rate is primarily a function of temperature and the residence time of nitrogen at that temperature

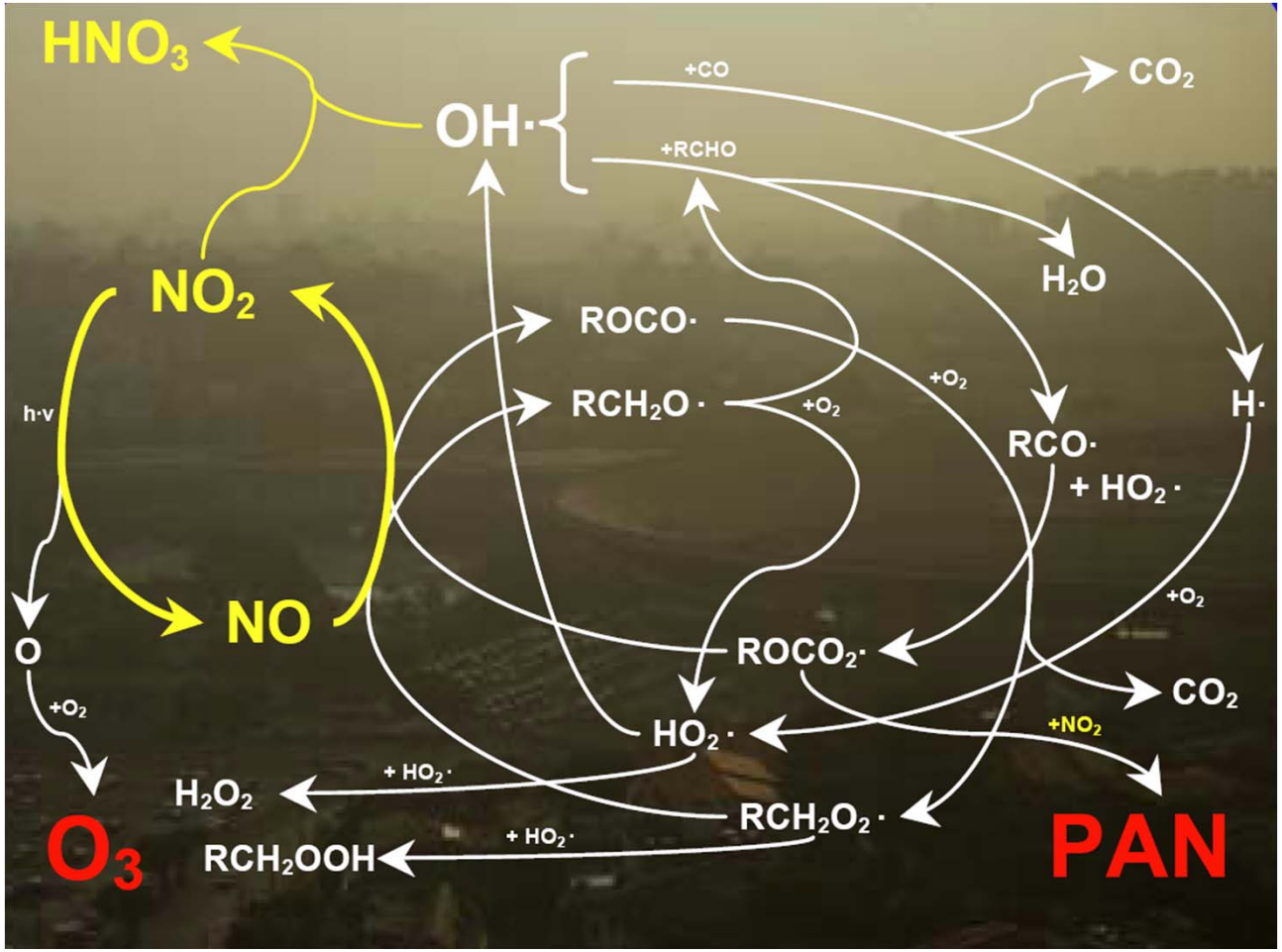
What is NOx?

Why is NO_x so harmful?

- NO is colorless, odorless and flavorless
- It poisons the blood => paralysis
- NO_2 is red-brownish gas with a pungent smell
- It is involved in the formation of ozone (O_3)
- In high concentrations it irritates the respiratory system
- In the atmosphere it reacts with H_2O and forms nitric acid (HNO_3) which is part of the acid rain

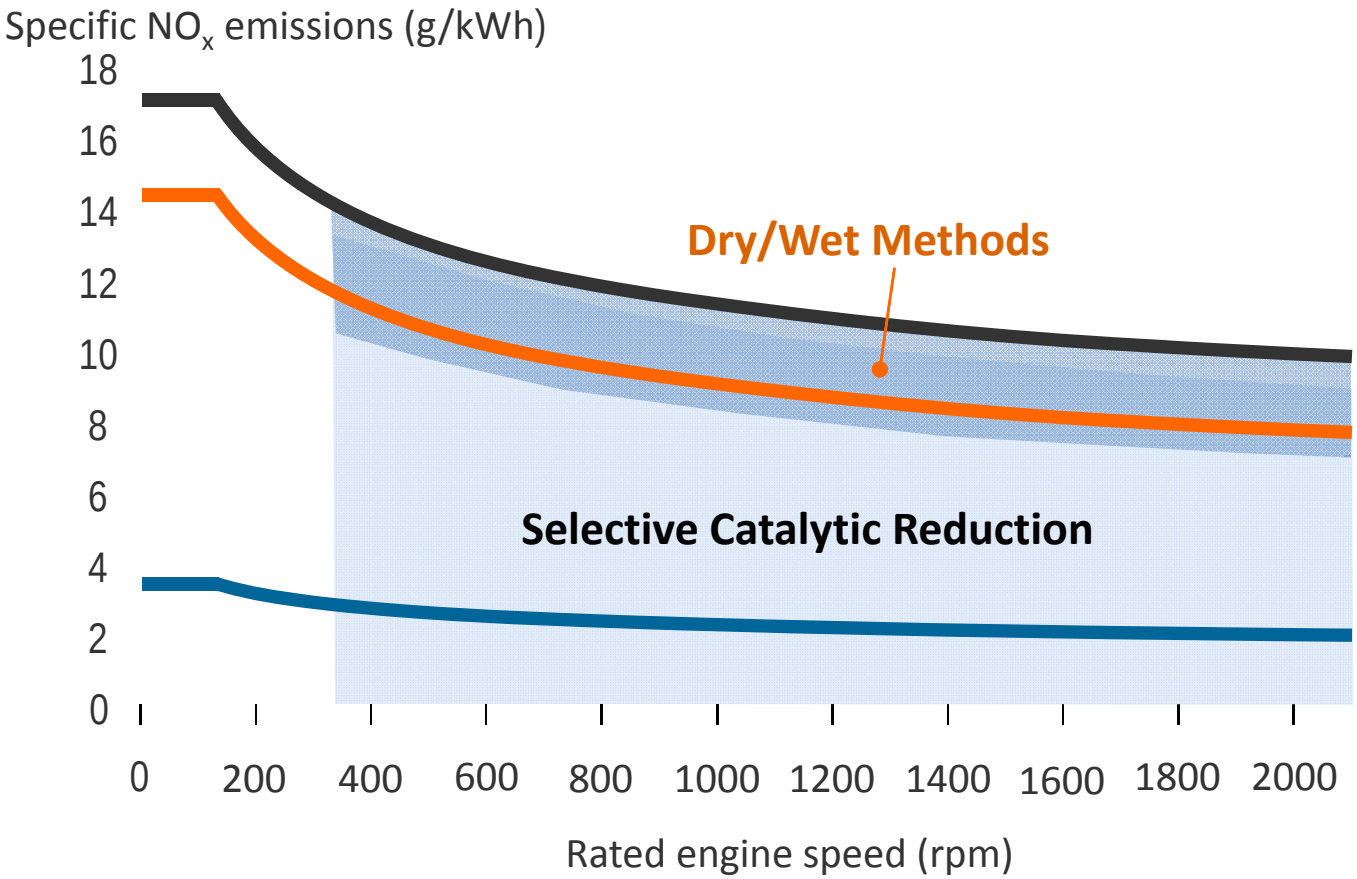
What is NOx?

Why is NO_x so harmful?



Source: B. Troegel, TU Braunschweig

Development of Emission Limits



Tier I (present)

Ships built 2000 onwards
Engines > 130 kW

Retrofit: Ships built 1990 – 2000
Engines > 90 litres/cylinder and > 5000 kW

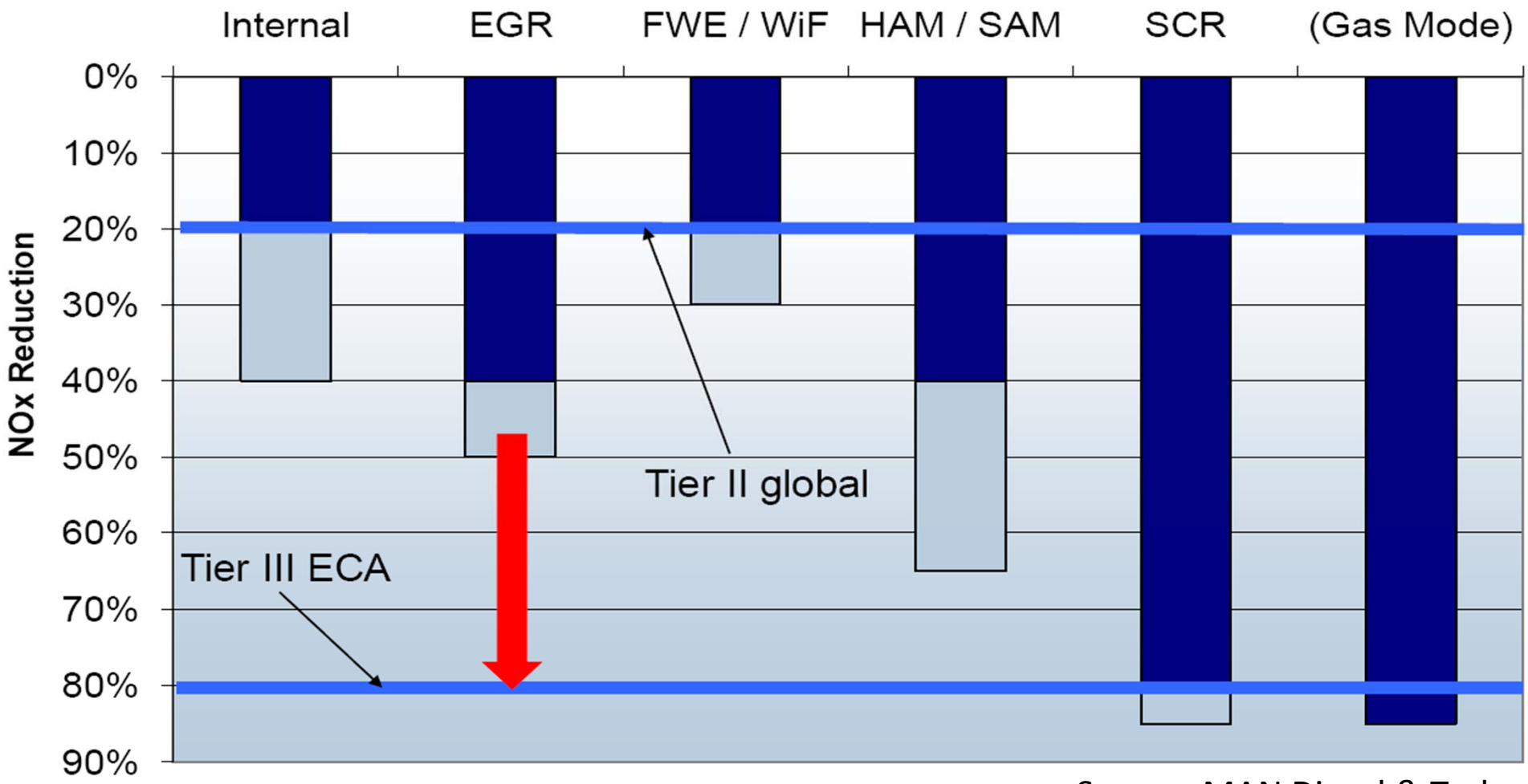
Tier II (global 2011)

Ships built 2011 onwards
Engines > 130 kW

Tier III

New builds 2016 onwards
Engines > 600 kW

Technologies for Reduction of NOx

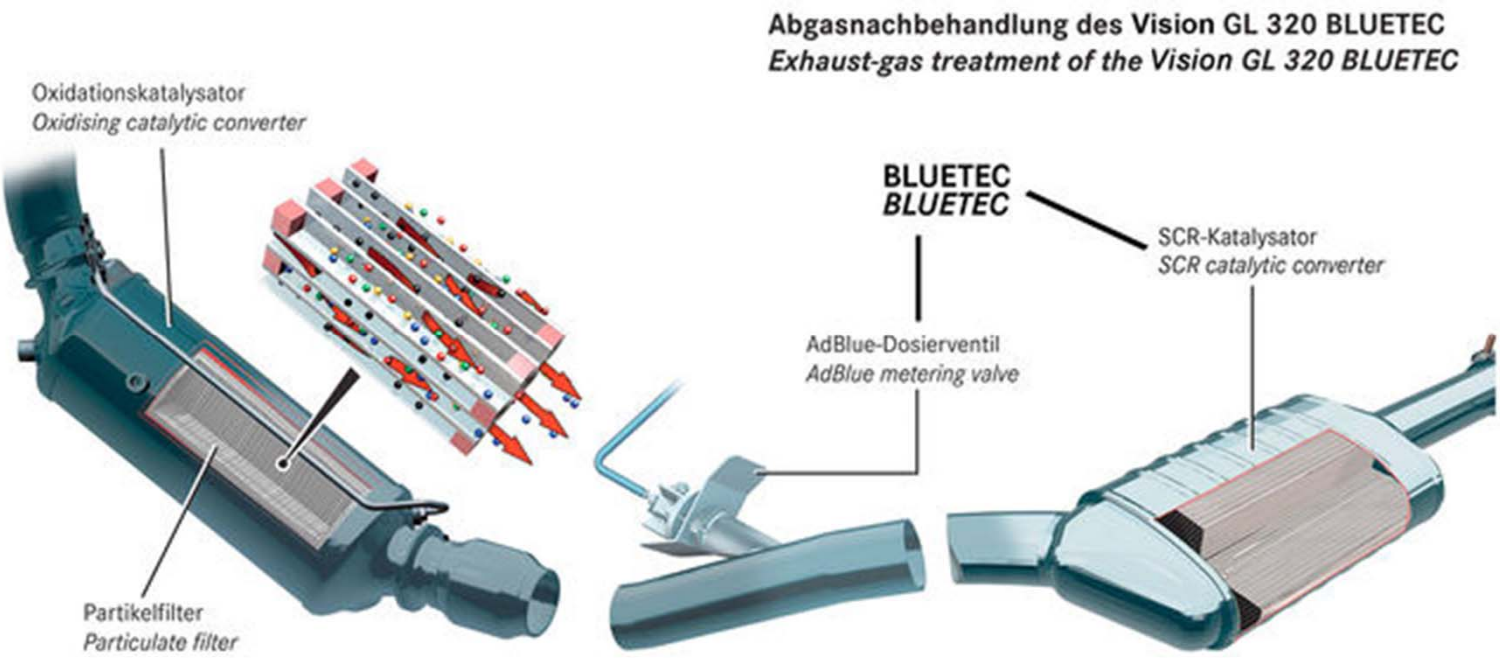


Source: MAN Diesel & Turbo

SCR Technology

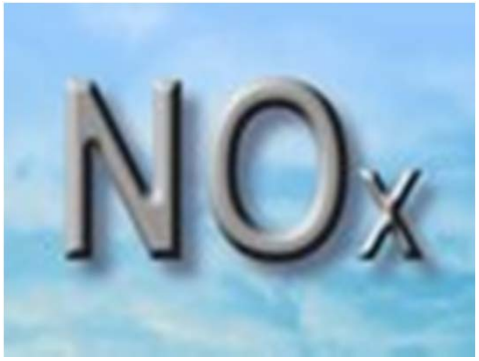
- 2 technologies for the abatement of NOx
  - Selective Non Catalytic Reduction (SNCR)
  - Selective Catalytic Reduction (SCR)
- SNCR requires high temperatures (900° - 1050°C)
  - Mainly used in boiler applications of power plants
  - Key factors for the process are temperature, dosing of reducing agent and distribution of reducing agent across the boiler
- SCR is widely used in power plants, waste incinerators, glass melting industry and automotive industry
- Both technologies utilize the same reducing agent: NH_3 = ammonia

SCR Technology



Diesel Dilemma?

Optimized Consumption



NOx-optimized Engine

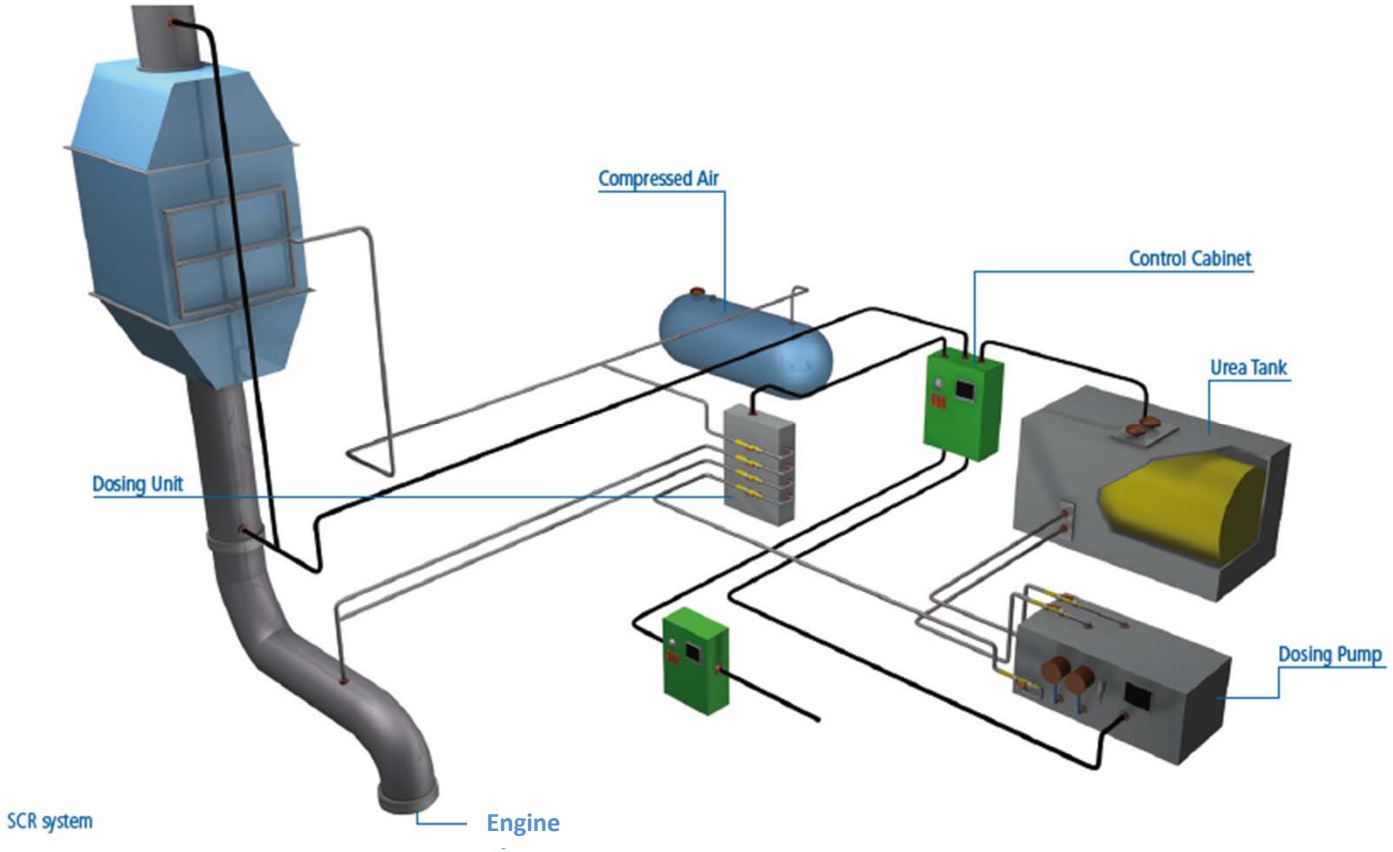
SCR Systems Overview

- App. 700 SCR systems installed onboard
  - Mainly 4 stroke engines
  - < 10 2-stroke engines
- Many installations inside funnel
- Silencer can be replaced to gain space or size of silencer can be reduced as SCR systems have a certain sound attenuation
- Tank for Urea solution larger than SCR

Why SCR today?

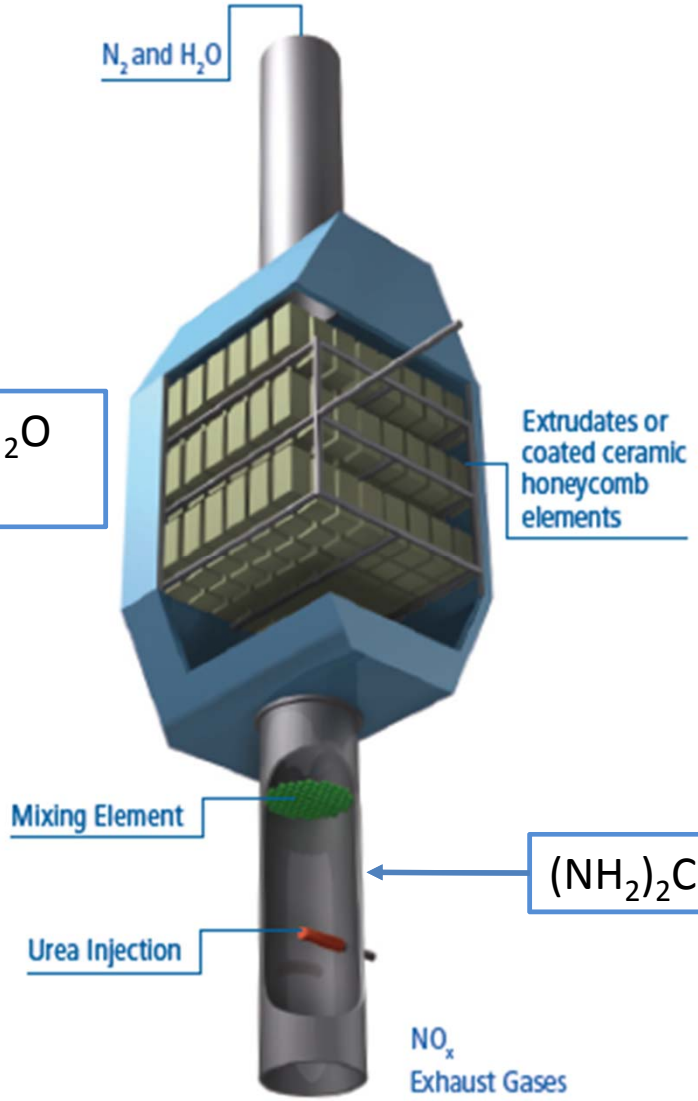
- Good for the environment and human health
- Reduced fees in harbours
- NOx funds (Norway, Sweden)
- App. 15% of global NOx emissions caused by shipping (≈ 25 Mill/t p.a.)

State of the art of SCR systems



$4NO + 4NH_3 + O2 \Rightarrow 4N_2 + 6H_2O$

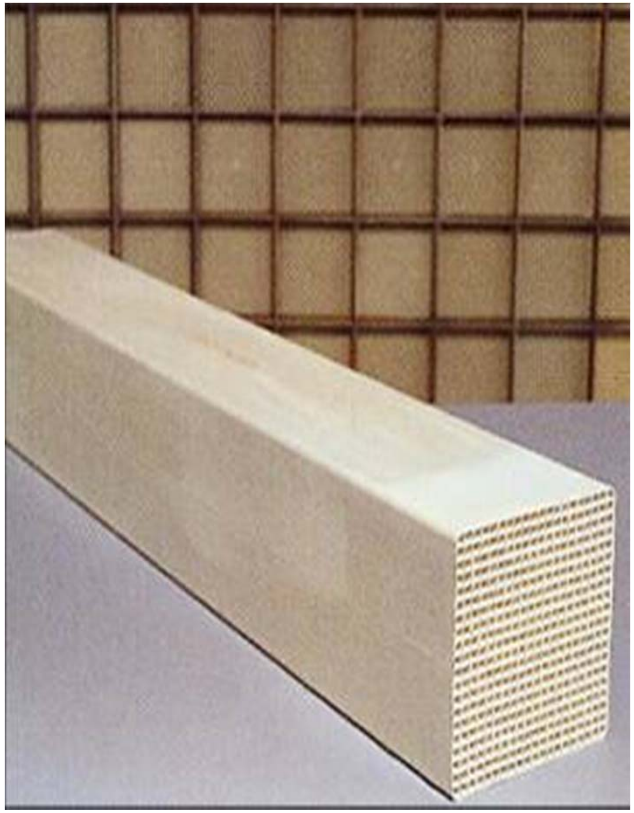
$6NO_2 + 8NH_3 \Rightarrow 7N_2 + 12\ H_2O$

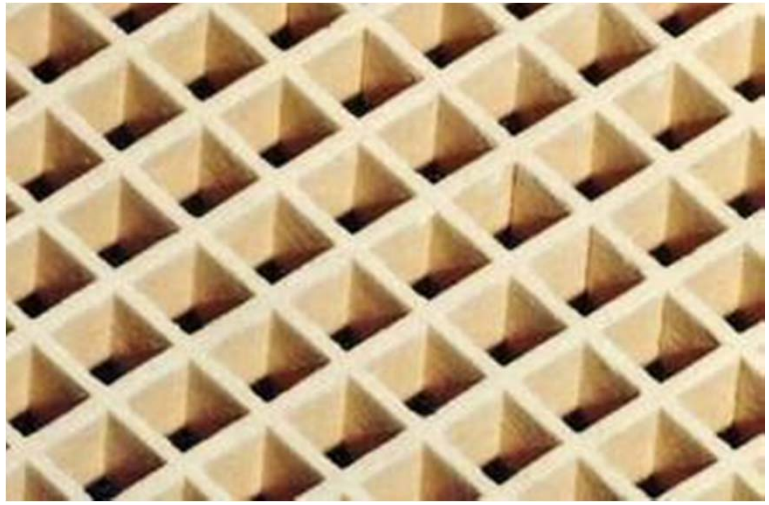


$(NH_2)_2CO + H_2O \Rightarrow NH_3 + CO_2$

Catalyst Elements

Catalyst Element

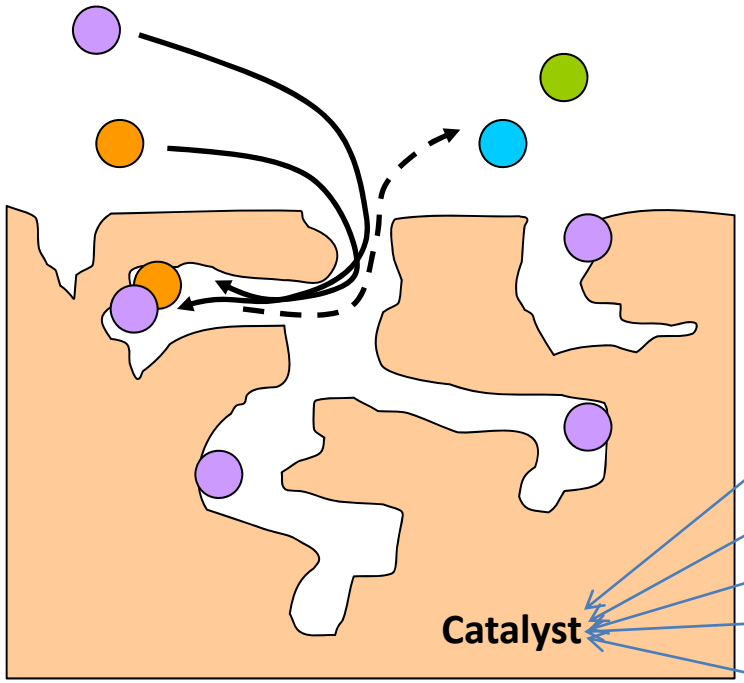




Catalyst Element

$4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$

$2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$



- NH_3
- NO
- H_2O
- N_2

Vanadium pentoxide V_2O_5

Tungsten trioxide WO_3

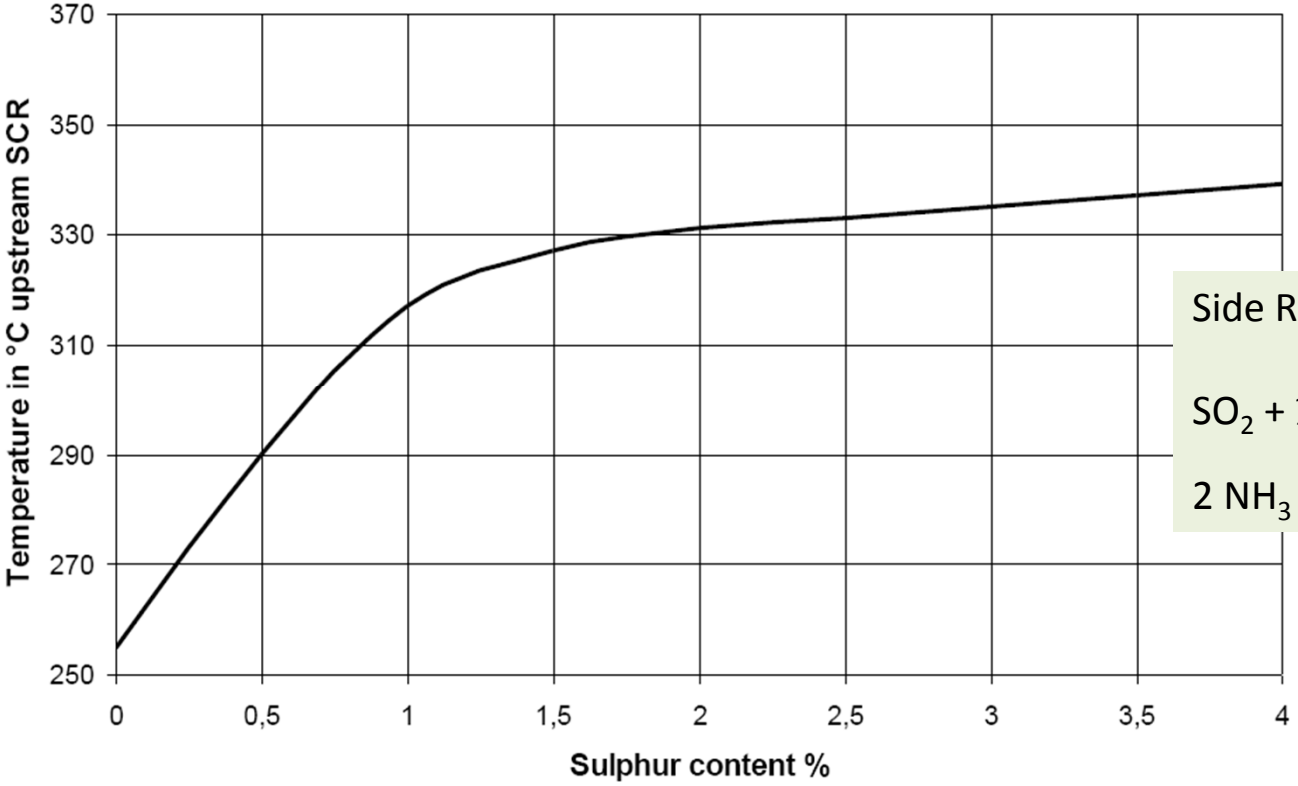
Aluminum oxide Al_2O_3

Titanium dioxide TiO_2

Platinum, Rhodium,

SCR Systems for 2-stroke and 4-stroke engines

Needed minimum temperature at SCR inlet to avoid ammonium sulphate formation

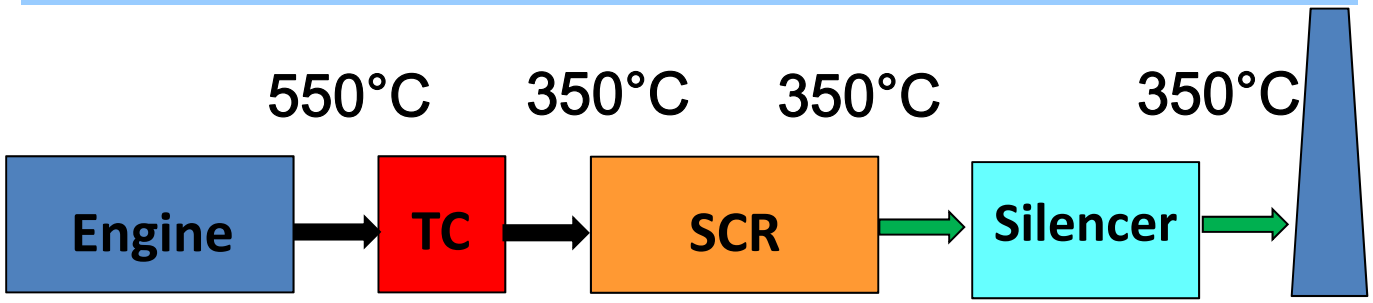


Side Reaction:

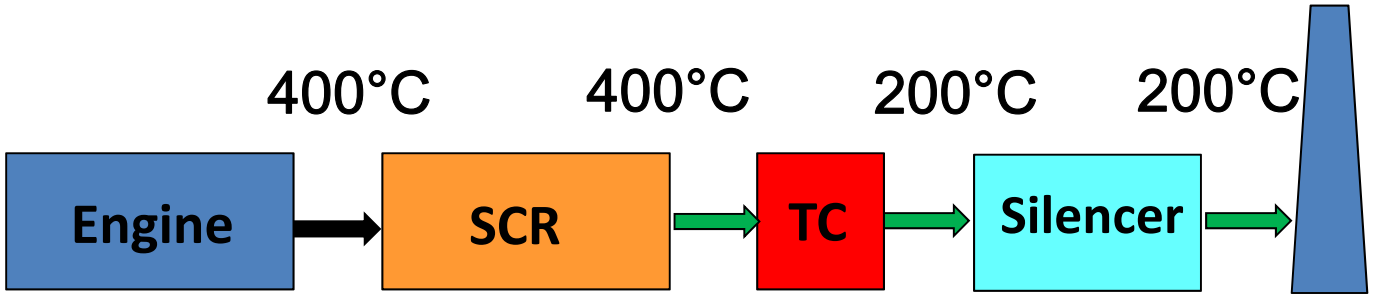
$SO_2 + ½ O_2 \rightarrow SO_3$

$2 NH_3 + SO_3 + H_2O \rightarrow (NH4)_2SO_4$

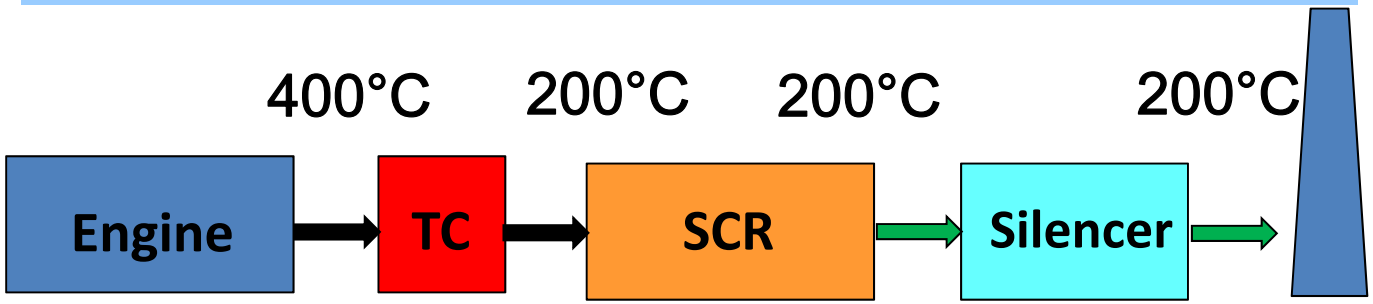
SCR-Arrangement 4-Stroke-Engine HFO-Operation

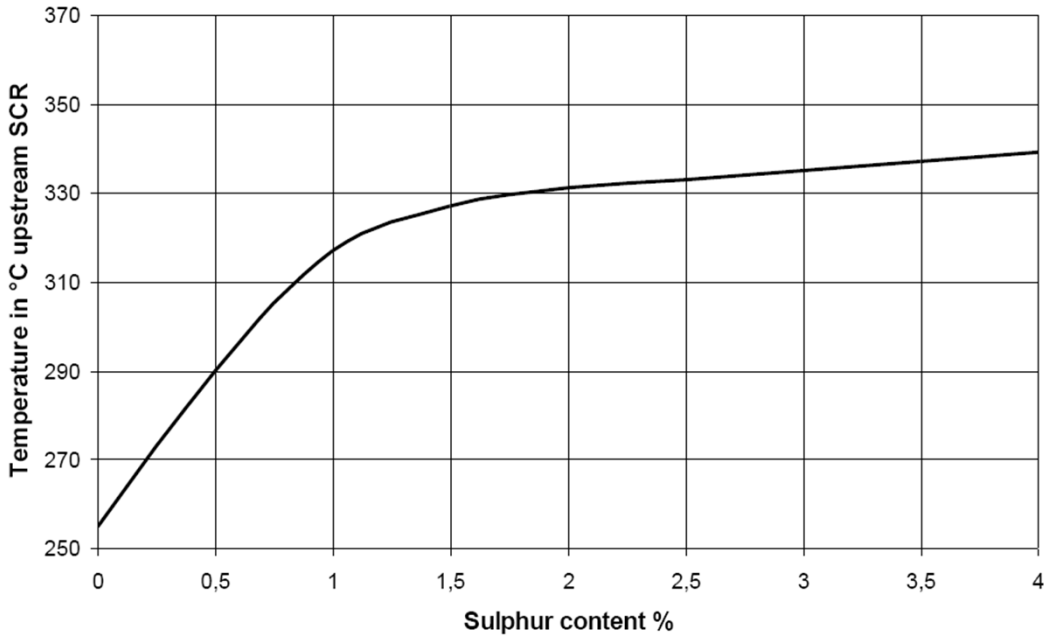


SCR-Arrangement 2-Stroke-Engine HFO-Operation

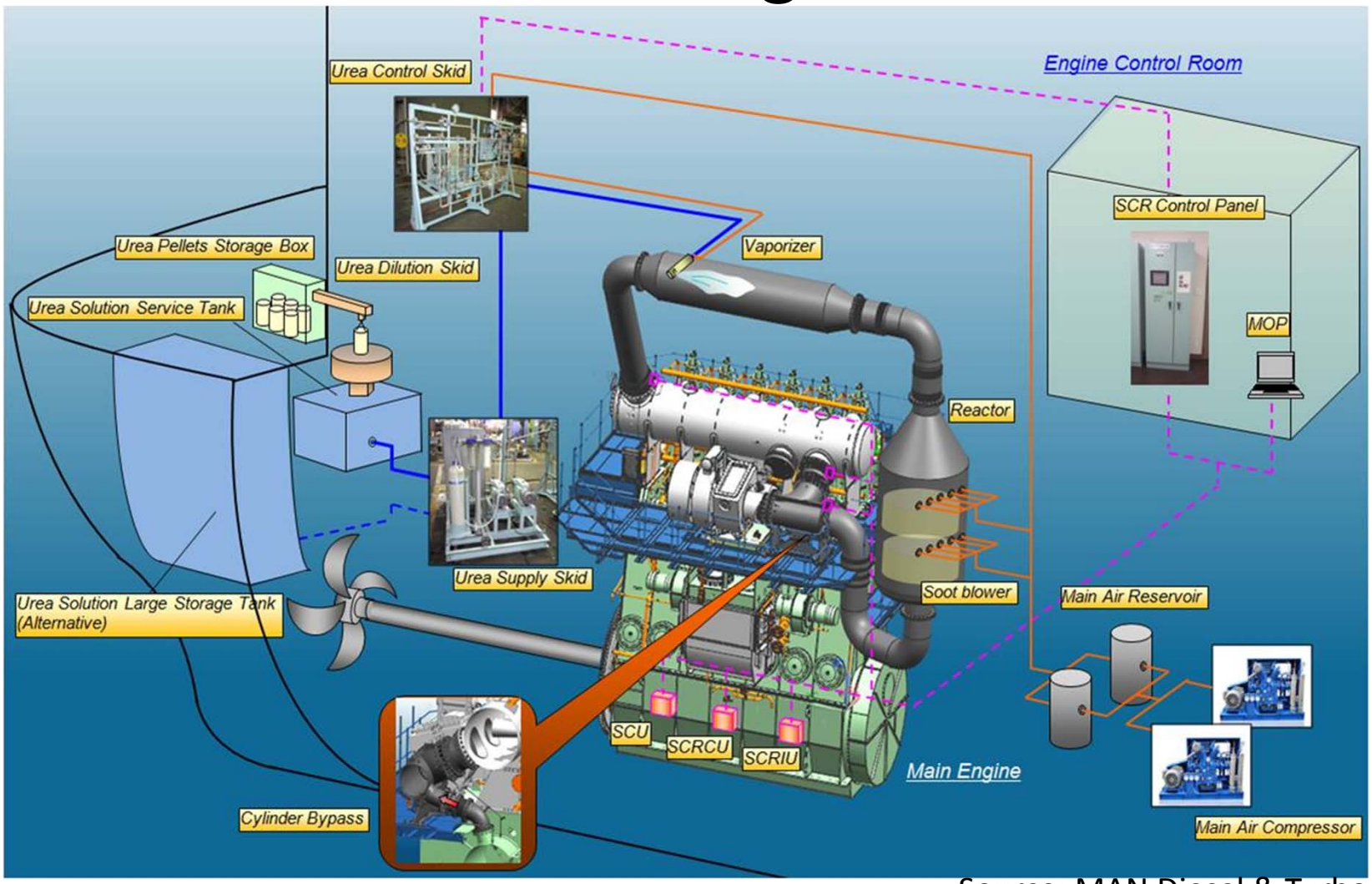


SCR-Arrangement 2-Stroke-Engine MGO-Operation



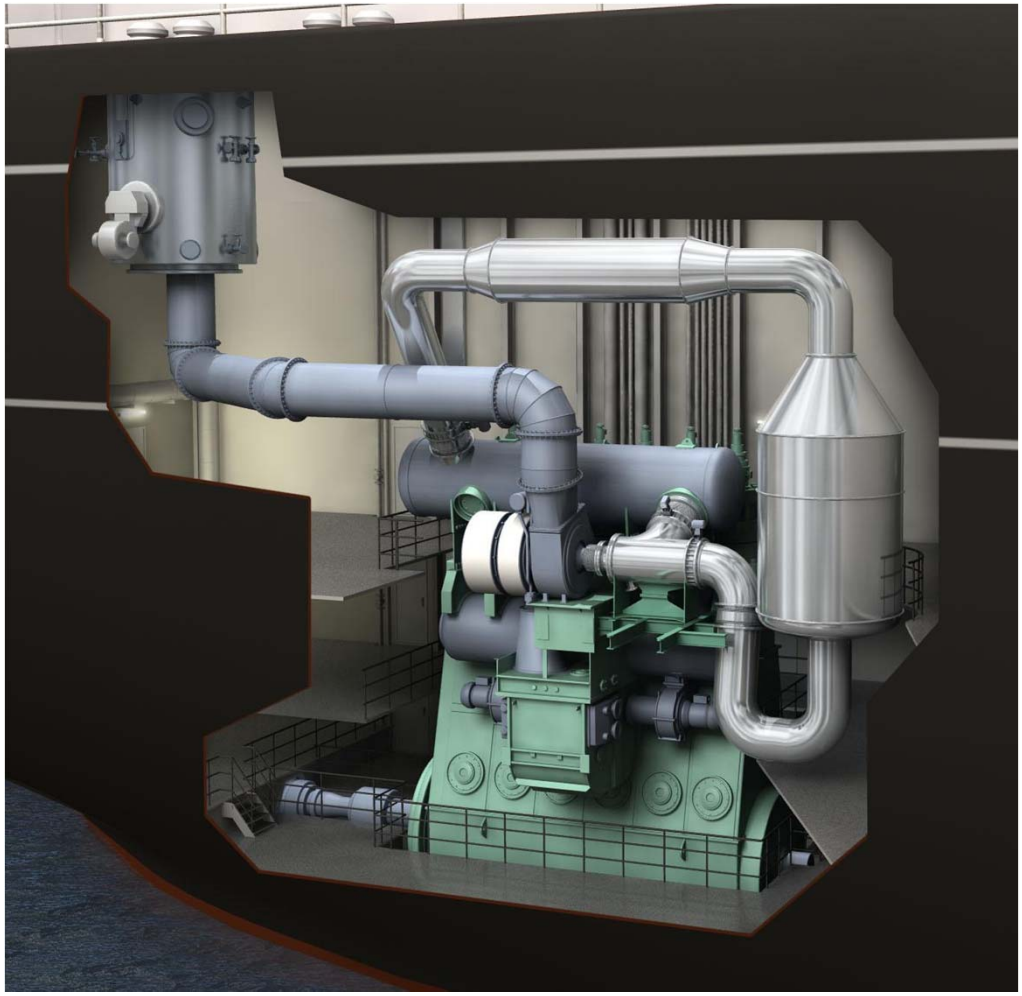


SCR for 2-stroke Engines



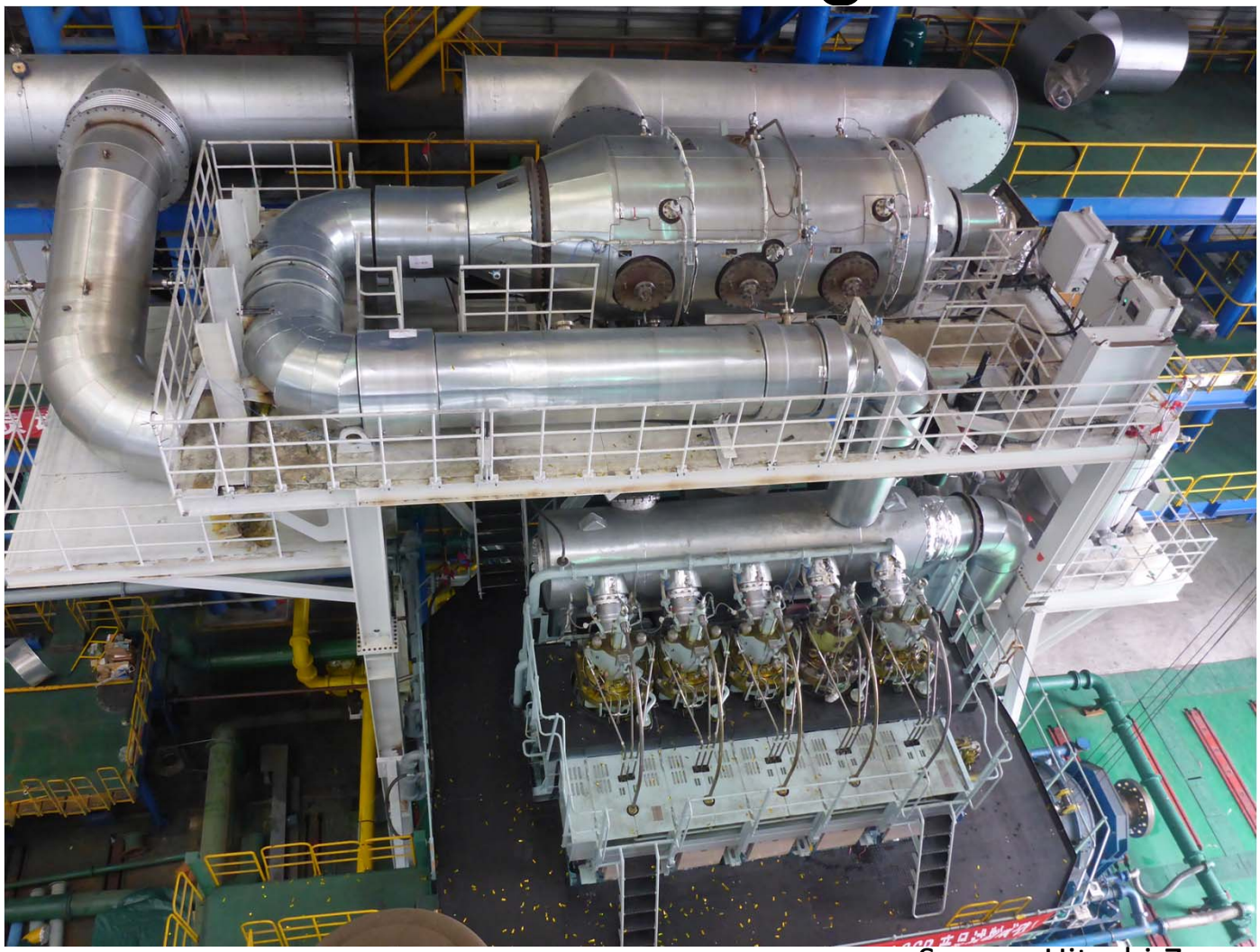
Source: MAN Diesel & Turbo

SCR for 2-stroke Engines



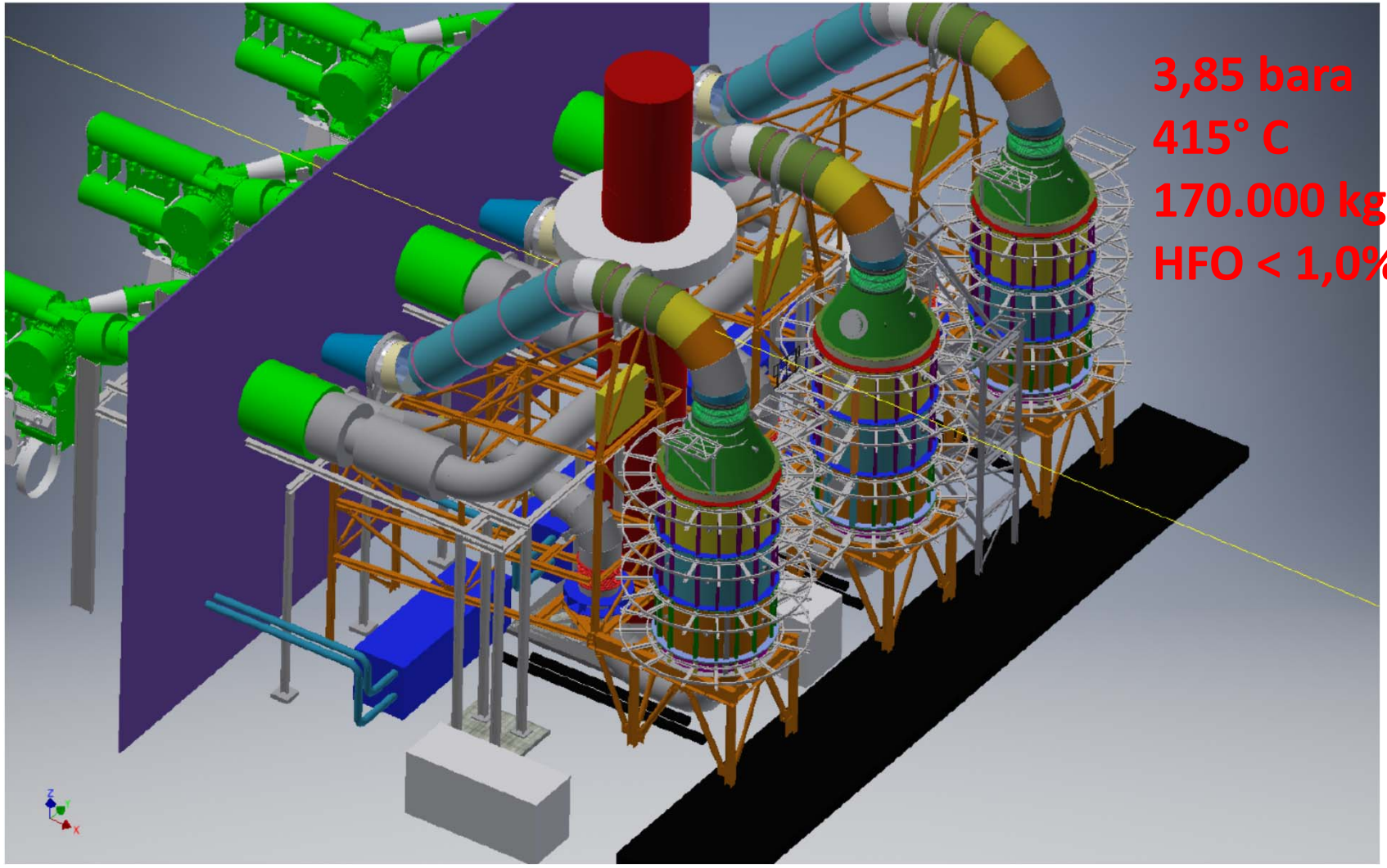
Source: MAN Diesel & Turbo

SCR for 2-stroke Engines



Source: Hitachi-Zosen

Actual Project: 3 x 12K50 @ 18.000 kW



SCR Casing for 4-stroke Engines

- Flow direction from buttom to top
- 1 Spare layer
- Soot blowing pipes
- deltaP monitoring
- NOx sensor

SCR for 4-stroke Engines

Summary

- SCR in maritime application is a proven technology
- Reliable technology to achieve lowest NOx values
- No SFOC penalty during operation
- In many cases a retrofit is possible
- Replacement of silencer is possible
- Refinancing of installation and operation by NOx funds within short payback time

Summary

PLEASE BE SAFE
AND HELP CARE FOR THE ENVIRONMENT
If you climb or sit on the railing you may fall in
The propellers will chop you up. The wildlife may eat you and get sick.

Vielen Dank für die Aufmerksamkeit

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