

US EPA ARCHIVE DOCUMENT

# Regulation 13.7.1 Approved Method

**Application:**     Ships constructed 1 Jan 1990 to 31 Dec 1999  
Marine diesel engine power output >5,000 kW  
Per cylinder displacement 90 litres

If a method has been approved by Party according to chapter 7 of the NOx Technical Code 2008 then ship is required to fit the “approved method” to enable the engine to meet Tier I limits.

**IMO to be notified of approved method**

**The approved method to be installed at first renewal survey  
12 months or more after IMO notified the “method” is approved**

Tier	$n < 130$ rpm	$130 \leq n < 2000$ rpm	$n \geq 2000$ rpm
I	17.0 g/kWh	$45.0 \cdot n^{(-0.2)}$ g/kWh	9.8 g/kWh



Johnson Matthey  
Catalysts

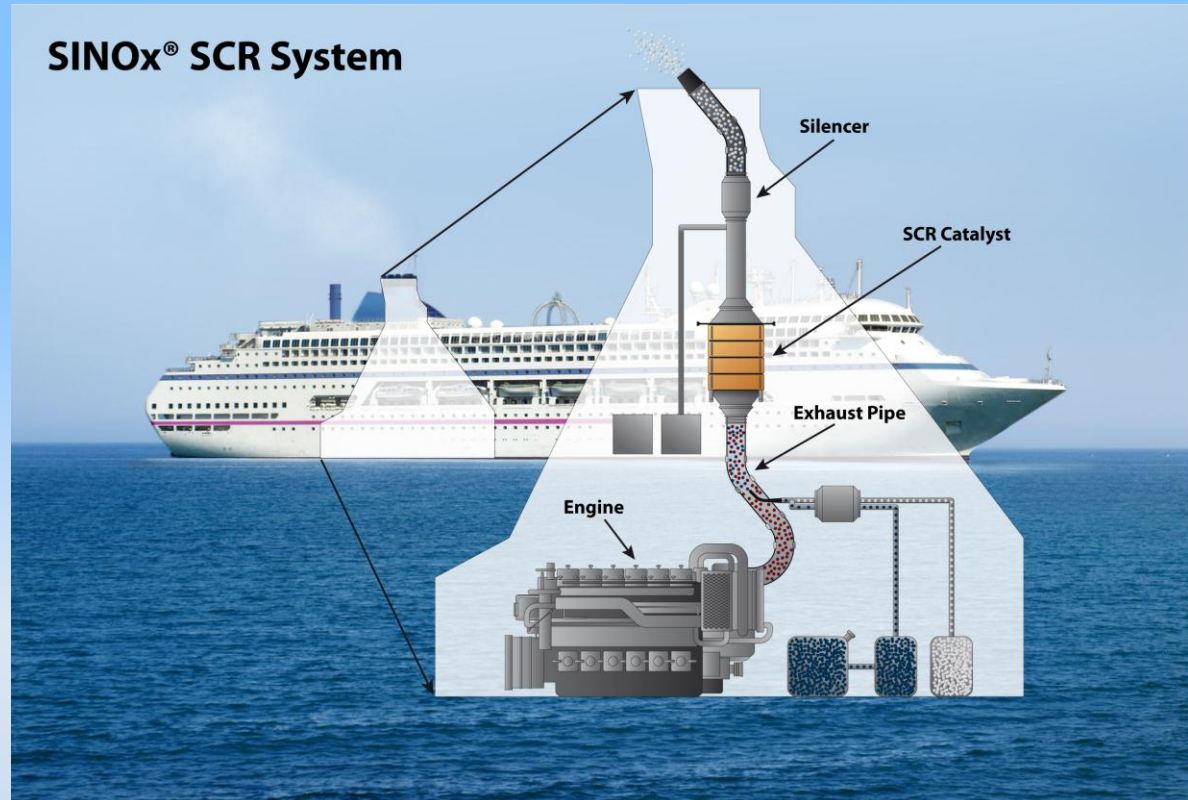
# Technology for meeting IMO III NO<sub>x</sub> limits

## Mexico Sept 26<sup>th</sup> Sept

Joseph Mc Carney  
Johnson Matthey



# International Association for Catalytic Control of Ship Emissions to Air





# **I**nternational **A**ssociation for **C**atalytic **C**ontrol of **S**hip **E**missions to **A**ir





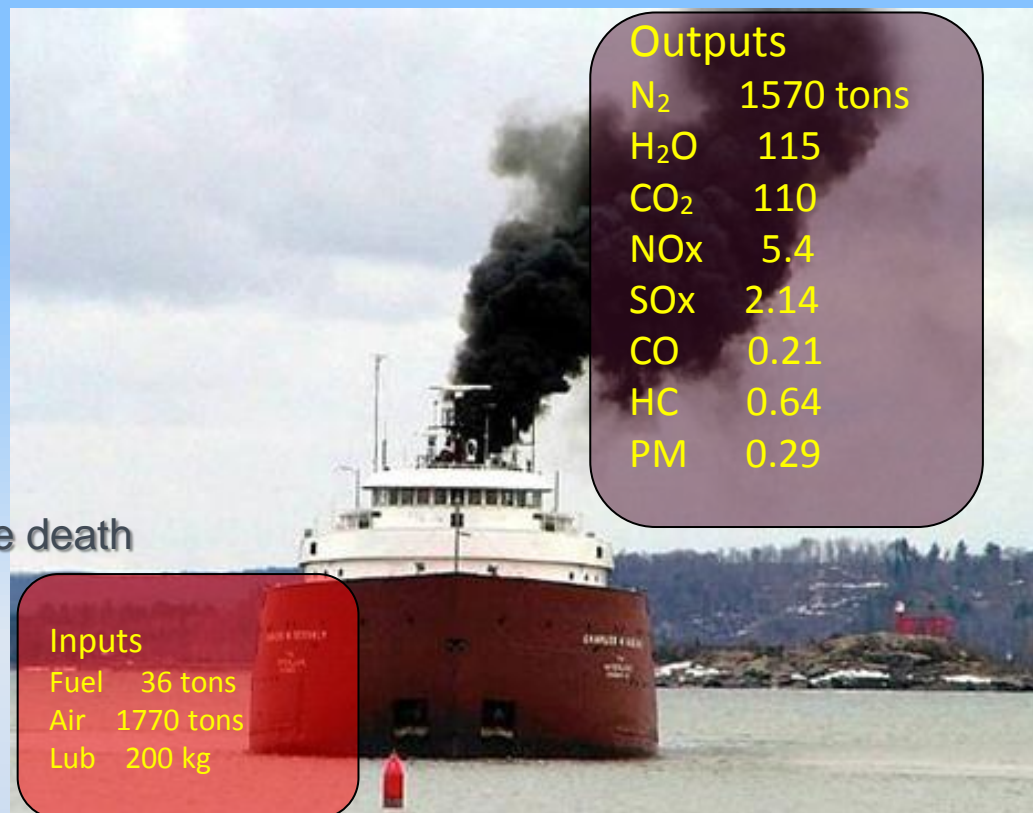
# A Major Player

- Speciality chemicals –advanced materials
- 1817    1942    2002    2008    2012
- Core skills in Catalysis, PGMs & Process Tech.
- Invest in R&D and Manufacturing Technology
- Operate in over 30 countries, 10000 employees
- Focus on Growth Opportunities - environment
- Technology & Market Leadership
- 160 SCR systems on ships – large and small



# A Major Contribution **NO<sub>x</sub>**

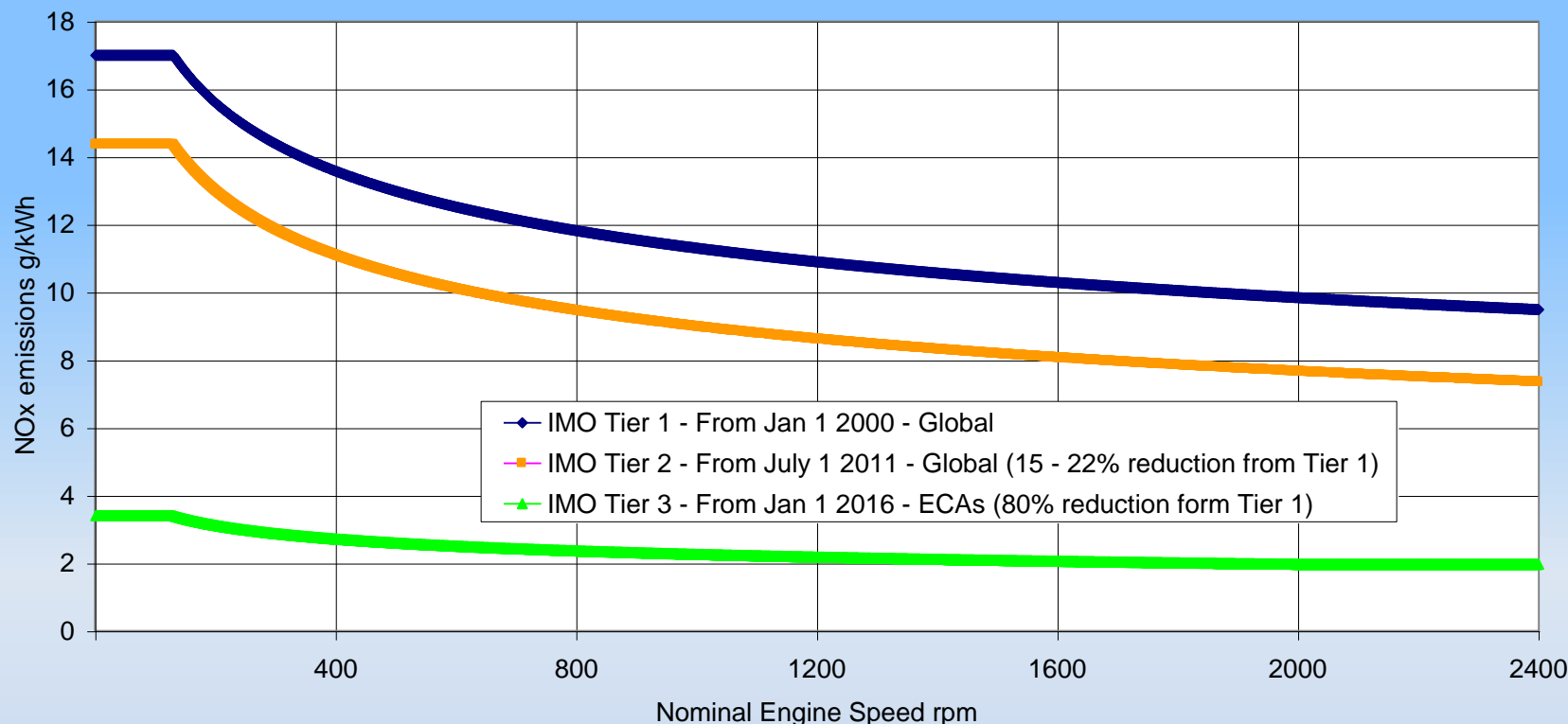
- Formed in the heat of the engine
- SMOG & Particulates
- Acidifies the environment
- Lung and heart disease
- Economic costs
  - Medical care
  - Lost Productivity
  - Cost of pain / ill health / premature death
- US EPA – ECA application
  - 14000 lives saved p.a
  - 5m experience relief – respiratory symptoms



# A Major Requirement

“IMO Tier III scripted to force after-treatment in NO<sub>x</sub> ECAs”

New IMO NO<sub>x</sub> Regulations for New Constructions (EIAPP Reg 13)



**“Beginning in 2012 and completed no later than 2013, the Organization shall review the status of the technological developments to implement the standards set forth in paragraph 5.1.1 of this regulation and shall, if proven necessary, adjust the time periods set forth in that subparagraph.”**

Regulation 13.10 of Annex 13, Resolution MEPC 176 (58):



# IMO Review-Terms of Reference

Exceptions & Exemptions

Range

NO<sub>x</sub> Review  
Of Technology Solutions  
To Meet IMO III

Applicability & Suitability

Status / Readiness  
Technology Trajectory  
Supply Chain Issues

# Contributors

Canada	Japan	BIMCO	ICOMIA
Denmark	Liberia	CLIA	ICS
Estonia	Netherlands	CSC	IMarEST
Finland	Norway	Euromot	INTERTANKO
France	Sweden	IACS	IPIECA
Germany	United Kingdom	IADC	OCIMF
Ireland	United States	IAPH	WSC
European Commission		Integer	IACCSEA

Disclaimer – The views set out in this document reflect the interpretation of the author – and do not necessarily concur with the interpretation of the IMO or other stakeholders

# Technology Options

## LNG

Fuel Combustion – controlled to  
Low NOx

## SCR

NH<sub>3</sub> neutralises NOx on Catalyst

## Other

Water Based / Valve Timing / TC  
Control combustion process in  
Diesel engine - Low NOx

## EGR

Lower O<sub>2</sub> content & lower  
Combustion Temperatures

# Technology Options

## Meeting IMO III NOx limits

### LNG

Fuel Combustion – controlled to  
Low NOx

### SCR

NH<sub>3</sub> neutralises NOx on Catalyst

### Other

Water Based / Valve Timing / TC  
Control combustion process in  
Diesel engine - Low NOx

### EGR

Lower O<sub>2</sub> content & lower  
Combustion Temperatures

# Technology Options - SCR

## State of Technology Readiness SCR

### Issue / Concern

Operating Conditions  
e.g. Temperature  
Catalyst Fouling – ABS  
Low Load Performance

SCR System - design  
Catalyst Lifetime  
Ammonia Slip  
Small Vessels

Supply Chain Concerns  
Urea

### Response

Flexibility -  
SCR reactor placement  
Charge Air, Timing, Burner  
Below 25% Load – SCR off

Experience-  
>16000 hours / 2 years  
Mobile, Stationary, Ships – 500  
Compact SCR – Design Phase

Competitive Global Supply Chain  
AUS 40 Standard  
US Supply Chain - by 2014





# Technology Options - EGR

## State of Technology Readiness EGR

### Issue / Concern

Technology Readiness  
Combined with other technology?  
Not available for most engines

H<sub>2</sub>SO<sub>4</sub> / PM  
Reagent / wash water

### Response

Capability Demonstrated  
High NO<sub>x</sub> reduction – IMO III  
Development Focus Engine OEMs

Low operating costs Mg(OH)<sub>2</sub>

Scrubber  
Developing Experience

# Technology Options - LNG

## State of Technology Readiness LNG

### Issue / Concern

Low emissions – dependent on  
Engine size / duty cycle / pilot fuel

Energy Density

### Response

Experience  
100's Gas engines – low emissions  
20 Vessels  
Meets IMO III  
Lower Fuel Costs

# Technology Options - Other

State of Technology Readiness – Other  
VVT, 2Stage TC... Water Based...

Issue / Concern

Response

Not Tier III Compliant  
30% - 50% - 65%  
DWI – HAM – FE

Can be used in combination

Miller Timing  
Decreased Power

Loss over come with 2-stage TC

# Technology Options - summary

## LNG

Fuel Combustion – controlled to  
Low NO<sub>x</sub>

Practical

## SCR

NH<sub>3</sub> neutralises NO<sub>x</sub> on Catalyst

Panacea

## Other

Water Based / Valve Timing / TC  
Control combustion process in  
Diesel engine - Low NO<sub>x</sub>

Partial

## EGR

Lower O<sub>2</sub> content & lower  
Combustion Temperatures

Potential

# Conclusion / Insight

Technology to meet IMO III limits is available  
There are a number of options / combinations

Greater collaboration between Engine OEMs and other technology providers will deliver efficient, economical, environmental solutions, for cleaner shipping

IACCSEA

Greater collaboration between technology providers and regulators will maximise the gain to society at an “efficient” cost

IACCSEA



# SCR installation – Alice Austen

**Engines:** 2 x CAT 3516 A  
**Temperature:** 752°F  
**NOx Reduction:** < 3 g/kWh (~ 70%)  
**SCR installed:** 2004



Staten Island Ferry (US)

# SCR installation – MS Timbus

<b>SINOx® Installed:</b>	<b>1999</b>
<b>Type</b>	<b>MaK 8M32 (Main)/ MAN 6L16/24 (Aux.)</b>
<b>Power</b>	<b>3,840kW / 540 kW (Aux.)</b>
<b>Exhaust Gas Flow</b>	<b>21,000 / 3,000 Nm<sup>3</sup>/h</b>
<b>Fuel</b>	<b>HFO / MDO</b>
<b>Temperature</b>	<b>320 / 336° C</b>
<b>Urea Consumption :</b>	<b>97 / 8 l/h (@40%)</b>



<b>Catalyst Type</b>	<b>SW 30 Honeycomb</b>
<b>Catalyst Volume</b>	<b>3 m<sup>3</sup>/engine (Main) 0.4 m<sup>3</sup>/engine (Aux.)</b>
<b>Exhaust NOx:</b>	<b>2g/kWh</b>



Johnson Matthey  
Catalysts

# SCR installation – Kleven

**Project:** Supply Vessel/Work ship Kleven  
**Exhaust gas flow:** 8.790 m<sup>3</sup>/h  
**Engine type:** 2 x MAN 6L 32/40, 2 x MAN 8L 21/31  
**Fuel:** MGO  
**Temperature:** 335° C  
**SINOx® Installed:** 2007

**Catalyst type:** SW 40  
**Catalyst volume:** 3.8 m<sup>3</sup>  
**NOx Reduction:** 86%





# SCR installation – LNG Carriers

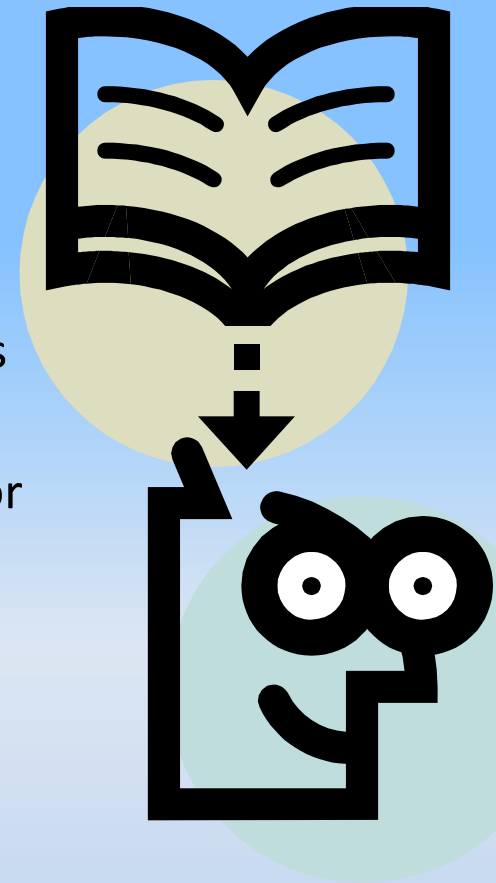
**Project:** 2 x LNG Carrier, Exmar Excellence/Excelerate  
**SINOx<sup>®</sup> Installed:** 2007  
**Exhaust Gas Flow:** 2 x 70.100 Nm<sup>3</sup>/h  
**Application:** 2 x 70t/h Regas Boiler  
**Fuel:** HFO/MDO  
**Temperature:** 380°C



**Catalyst Type:** SW 30 Honeycomb  
**Catalyst Volume:** 10,62 m<sup>3</sup>  
**Exhaust NOx :** 30 mg/Nm<sup>3</sup>  
**Reduction Rate:** 93%

# De-NOx - Selective Catalytic Reduction

- 1. Combustion → pollution inc. the acidic pollutants - NO<sub>x</sub> & SO<sub>x</sub>
- 2. NO<sub>x</sub> is dangerous, & increasingly its emission is regulated.
- 3. NO<sub>x</sub> can be controlled in the engine or neutralised in the tailpipe – via catalytic after treatment such as SCR
- 4. SCR is a proven technology (power-plants ,HDD and auto)
- 5. The SCR process produces Nitrogen as its end product
- 6. Marine SCR – >500 Case studies – yachts to container ships
- 7 SCR needs a reducing agent – Urea / Ammonia
- 8 The catalyst is robust but requires the correct conditions for optimum operation
- 9. Sulphur is not a poison to Marine SCR Catalysts – but its effects need to be considered – e.g. limiting temperature.
- 10. After-treatment can allow an increase in efficiency (fuel
- 11. SCR on its own can meet IMO III or as a top up technology







Johnson Matthey  
Catalysts

Technology for IMO III

Mexico Sept 26<sup>th</sup> Sept

For Further information please contact

Joseph Mc Carney

Johnson Matthey

[mccarj@matthey.com](mailto:mccarj@matthey.com)

EMISSION CONTROL TECHNOLOGIES

