



Regulatory Update on Air Emissions

Thomas Kirk
Director, Environmental Performance

Stamatis Fradelos
Principal Engineer, OEP

Hamburg
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Copenhagen
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Istanbul
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Monaco
3 May 2016

Agenda

- Regulatory Framework: Emissions
- NO_x, SO_x, PM: Reduction Potential Solutions
- Volatile Organic Compounds (VOCs)
- CO₂: EU Monitoring, Reporting & Verification

Prevention of Air Emissions

- Regulation 12 – Ozone Depleting Substances (ODS)
- Regulation 13 – Nitrogen Oxides (NO_x)
- Regulation 14 – Sulfur Oxides (SO_x) and Particulate Matter
- Regulation 15 – Volatile Organic Compounds (VOCs)
- Regulation 16 – Shipboard Incineration
- Regulation 21 – CO₂ by means of Required EEDI

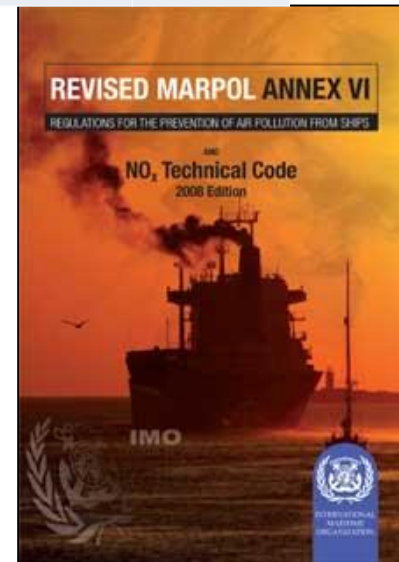
For Engines Output > 130 kW

- Ships KL ≥ 1 Jan. 2000 < 1 Jan 2011 – Tier I
- Ships KL ≥ 1 Jan. 2011 – Tier II
- Ships KL ≥ **1 Jan. 2016** – meet:
 - Tier II outside ECA
 - **Tier III in ECA**

Annex VI Special Areas	Amendments to MARPOL	Entry into force of amendments	In effect from
Baltic Sea (SO _x)	26 Sept 1997	19 May 2005	19 May 2006
North Sea (SO _x)	22 Jul 2005 (MEPC.132(53))	22 Nov 2006	22 Nov 2007
North American (SO _x , and NO _x and PM)	26 Mar 2010 (MEPC.190(60))	1 Aug 2011	1 Aug 2012
Caribbean Sea (SO _x , NO _x and PM)	15 Jul 2011 (MEPC.202(62))	1 Jan 2013	1 Jan 2014

- < 1 July 2010: 1.5% S in ECA
- ≥ 1 July 2010: 1.0% S in ECA
- < 1 Jan. 2012: 4.5% S
- ≥ 1 Jan. 2012: 3.5% S
- **≥ 1 Jan. 2015: 0.1% S in ECA**
- **≥ 1 Jan. 2020 or 2025: 0.5% S**

- Ships Contract ≥ 1 Jan. 2013 : meet EEDI
- Ships KL ≥ 1 July 2013 (In absence of contract date): meet EEDI
- **Delivered ≥ 1 July 2015**



NOx, SOx, PM: Reduction Potential Solutions

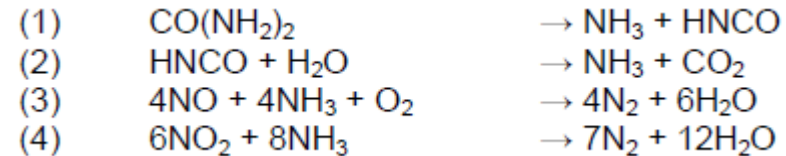
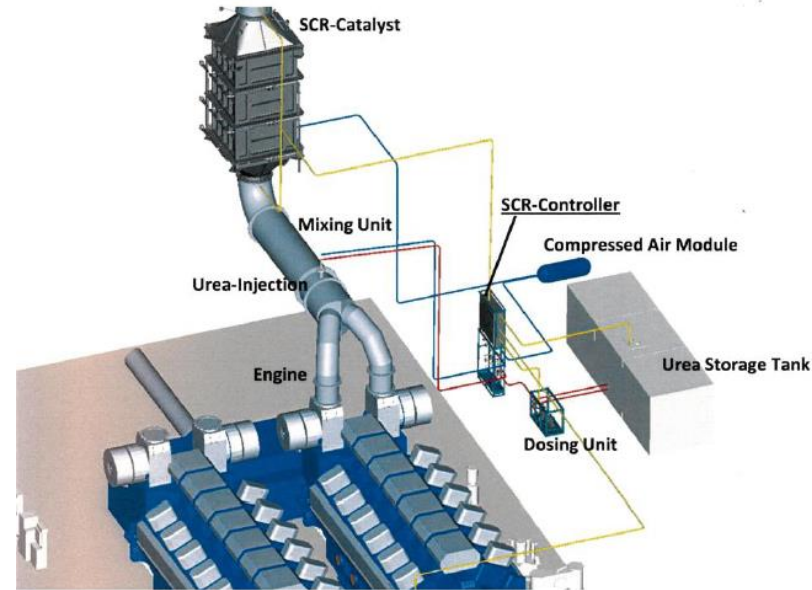
- Use alternative fuels (i.e. LNG)
- Infrastructure measures (i.e cold ironing)
- Selective Catalytic Reduction (SCR)
- Exhaust Gas Recirculation (EGR)
- Exhaust Gas Cleaning System (EGCS)
- Fuel switching to low sulphur residuals and distillates oils

Technology	NOx	SOx	CO ₂	PM
Use LNG as fuel	yes	yes	yes	yes
Infrastructure measures (i.e cold ironing)	yes	yes	yes	yes
Selective Catalytic Reduction (SCR)	yes	-	-	-
Exhaust Gas Recirculation (EGR)	yes	-	-	yes
Exhaust Gas Cleaning System (EGCS)	-	yes	-	yes
Switching to low sulphur fuel oil	-	yes	-	yes

- Means negative, negligible or positive effect.

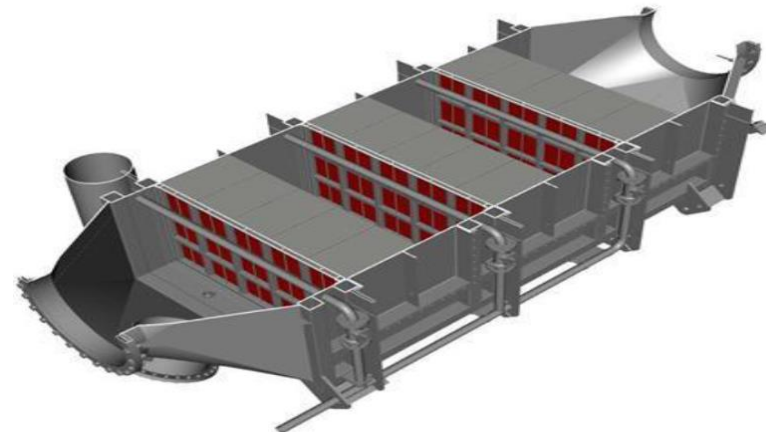
NOx: Selective Catalytic Reduction (SCR)

- Over 500 ships over the past 20 years
- Consists of:
 - Reducing agent storage tank
 - Reducing agent feeding/dosing unit
 - Injector and mixer
 - Reactor with catalyst elements
 - A control system
- The reducing agent used is often a solution (40%) of urea ($\text{CO}(\text{NH}_2)_2$)
- Urea is not defined as a hazardous material, as it has corrosive effects, the tank must be a suitable material
- The catalyst elements are normally dimensioned according to the need to meet the expected catalyst lifetime of 3 to 6 years or 12,000 to 24,000 running hours
- The minimum temperature is typically between 280°C and 340°C . The upper temperature limit is 400 to 450°C .



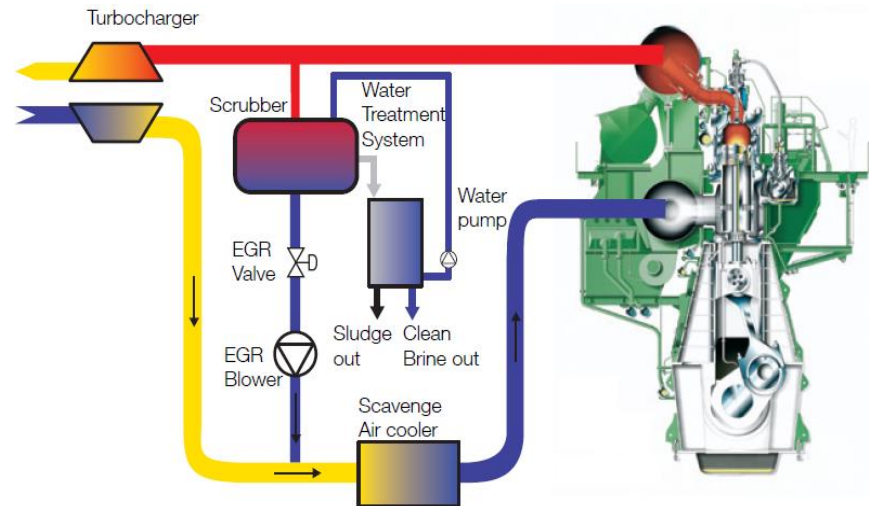
NOx: Selective Catalytic Reduction (SCR)

- The IMO Tier III NOx limits are measured on the EIAPP test cycle (paragraph 3.2 of NOx Technical Code 2008, as amended) and SCR operation is required to be tested on the test bed at 25%, 50%, 75% and 100% engine load points
- Urea increases CO₂ emissions by 1% as typical urea consumption is about 6.5 g/kWh resulting in about 4.8 kg CO₂/MWh and engine typical CO₂ emissions are 600 to 650 kg CO₂/MWh
- Soot blowing should be periodically activated to avoid fouling of unburned fuel and lubricating oil and remove dust and deposits from the catalyst layers
- An EGCS can be installed before or after a SCR unit to meet SOx and NOx ECA requirements
 - Before the SCR unit: the exhaust would need to be dried/heated prior to the SCR unit
 - After the SCR unit: the SCR unit would be designed for the use of higher sulphur fuel oils
- Used SCR elements are treated as hazardous material and have to be handled in line with the local disposal laws
- SFOC increase:
 - 2-3 g/kWh at low loads
 - 0 g/kwh when the engine load is sufficient to ensure proper exhaust gas temperature



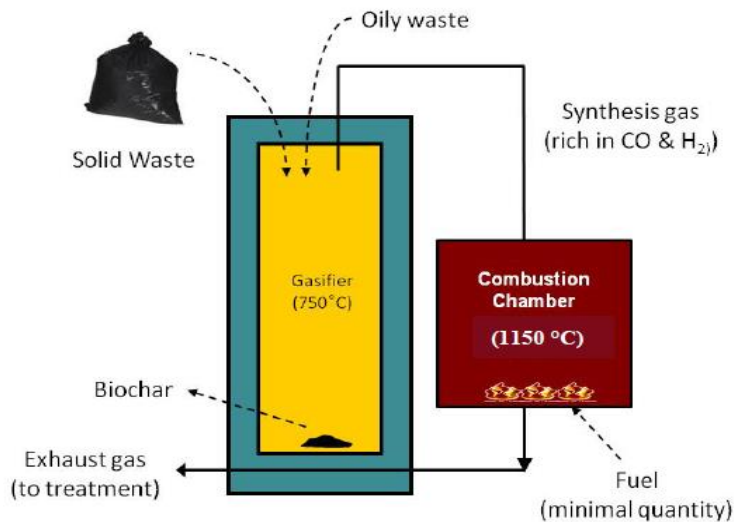
NOx: Exhaust Gas Recirculation (EGR)

- EGR was first considered for marine-2-stroke-development in the early 1980s
- Recirculation of a portion of the exhaust gases, typically 20 to 40%
- Lowered amounts of oxygen and increased heat capacity result in decreased combustion temperatures which reduce the NOx formation
- Mainly consists of a:
 - Exhaust gas wet scrubber
 - A control valve
 - A high pressure blower
 - A water treatment system
 - A control unit for controlling the water treatment system
 - A NaOH dosing system
 - Sludge tank
- Specific SFOC increase: 1-2g/kWh at all loads
- Scrubber of the EGR system has to comply with the washwater discharge criteria, of IMO Resolution MEPC.184(59)



Regulation 16: Shipboard Incineration

- MEPC 67/16 for Standard Specification of Shipboard Gasification Waste to Energy Systems
 - Amendments to regulation 16 of MARPOL Annex VI
 - A ship may operate a waste to energy system as an alternative to incineration
 - Draft Standard specification for shipboard gasification waste to energy systems
 - A vessel may operate waste to energy system it in port, subject to the requirements of the port State Administration



Form of IMO Type Approval Certificate for Shipboard Waste to Energy Gasification Waste to Energy Systems with capacities of up to 100 100 kg/hour

CERTIFICATE OF SHIPBOARD GASIFICATION WASTE TO ENERGY SYSTEM

NAME OF ADMINISTRATION

BADGE OR CYPHER

This is to certify that the Shipboard Gasification Waste to Energy System listed has been examined and tested in accordance with the requirements of the standard for Shipboard Gasification Waste to Energy Systems for disposing of ship generated waste MEPC.xxx(xx).Gasification Waste to Energy System manufactured by

Style, type or model for the Gasification Waste to Energy*

Max. capacity kW or kcal/h

..... kg/h of specified waste

O₂ Average in combustion chamber / zone%CO Average in flue gas ppm

H₂ Average in flue gasppm

Soot number average Bacharach or ringelman scale

Combustion chamber flue gas outlet temperature average°C

Char residue (solid waste)% by weight

Char residue (sludge oil)% by weight

Flue gas temperature after quench°C

Wash water bleed-off – pH

Wash water bleed-off – PAH µg/litre

Wash water turbidityFNU or NTU *

Energy output.....kW/hr

Energy type (select one).....thermal, refrigeration/air conditioning, electricity

A copy of this certificate should be carried on board a ship fitted with this equipment at all times.

Signed

Official stamp Administration of

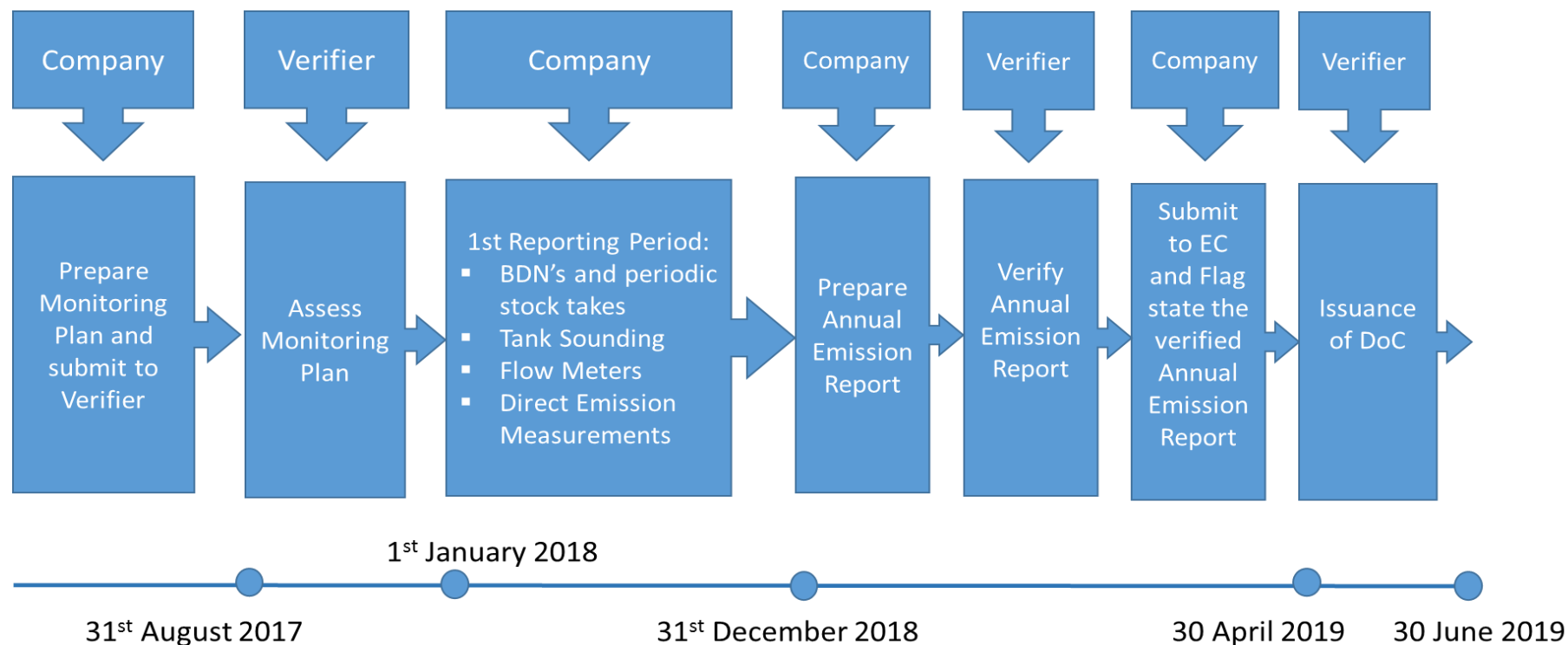
Dated this day of 20 ..

* Delete as appropriate

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CO₂: EU Monitoring, Reporting & Verification

- EC published proposal for CO₂ emissions MRV Regulation on 28 June 2013
- Approved by EU Parliament on 29 April 2015 as Regulation (EU) 2015/757
- Entry into force: 1 July 2015
- Ships above 5,000 GT on voyages to, from and between EU ports



Monitoring Plan – Article 6

- The identification and type of the ship
- Company name and address
- Description of the emission sources on board
- Description of procedures, systems and responsibilities used to update the completeness of emission sources and voyages data
- A description of the procedures for monitoring fuel consumption of the ship
- Emission factors used for each fuel type
- Procedures used for determining activity data per voyage
- Method to be used to determine surrogate data for closing data gaps
- Revision record sheet to record all the details of the revision history

COMPANY CO2 EMISSIONS MONITORING PLAN

COMPANY NAME

FLEET CO2 EMISSIONS MONITORING PLAN



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Monitoring Requirements

Per-voyage Basis	Annual Basis
Port departure/arrival including date and time of departure/arrival	Aggregated CO ₂ emissions from all voyages in/out and between EU ports
Amount and emission factor for each type of fuel consumed	Amount and emission factor for each type of fuel consumed in total
CO ₂ emitted	Total aggregated CO ₂ emitted
Distance travelled	Total distance travelled
Time spent at sea	Total time spent at sea
Cargo carried	CO ₂ emissions which occurred within ports at berth in EU ports
Transport work	Total transport work and average energy efficiency

- The annual emission report shall contain the parameters of the second column (Annual Basis)
- Specific information relating to the ship's ice class notation and to its navigation through ice could be included.



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