



# ABS TRENDS

Update on Operational Performance and Environmental Issues

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## Nitrogen Oxides (NO<sub>x</sub>) Emission Compliance Inside Emission Control Areas (ECAs)

1 January 2016 is another important date for a regulatory change where the MARPOL Annex VI, Regulation 13 for Tier III emission standards for ships constructed on or after 1 January 2016 and operating within the existing IMO Emission Control Areas (ECAs) will be enforced. Currently there are two NO<sub>x</sub> ECAs, the North American and the US Caribbean Sea, whereas there are four Sulphur Oxides (SO<sub>x</sub>) ECAs including the Baltic Sea and the North Sea.

The NO<sub>x</sub> Tier III standards will be applicable to marine diesel engines installed:

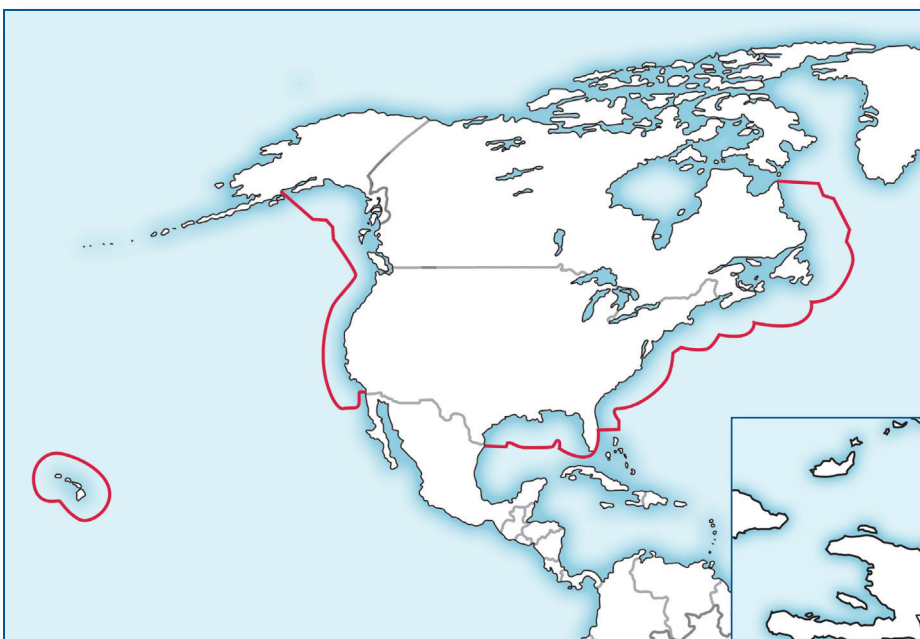
- on ships constructed on or after 1 January 2016 and which will operate in existing NO<sub>x</sub> ECA's (i.e., North American ECA or the US Caribbean Sea ECA); and

- on ships constructed on or after the date of adoption of a new ECA, or a later date as may be specified in the amendment designating the new ECA, whichever is later and which will operate in the new ECA.

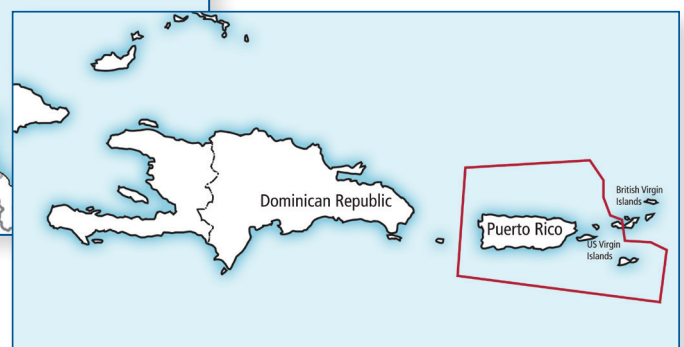
(Note: ships constructed means ships the keels of which are laid or that are at a similar stage of construction.)

Exemptions are provided for marine diesel engines installed:

- on purely recreational ships with a length < 24 m
- on a ship with a combined propulsion power < 750 kW if it is demonstrated that the ship cannot comply with Tier III because of design or construction limitations of the ship; and
- on purely recreational ships constructed prior to 1 January 2021 of less than 500 GT and with a length ≥ 24 m.



North American and US Caribbean Emission Control Areas



NOx Tier III emission standards reflect an 80% reduction from NOx Tier I emission standards as enforced on 1 January 2000 and subsequently followed by NOx Tier II emission standards, enforced on 1 January 2011.

### U.S. flag vessels additional requirements

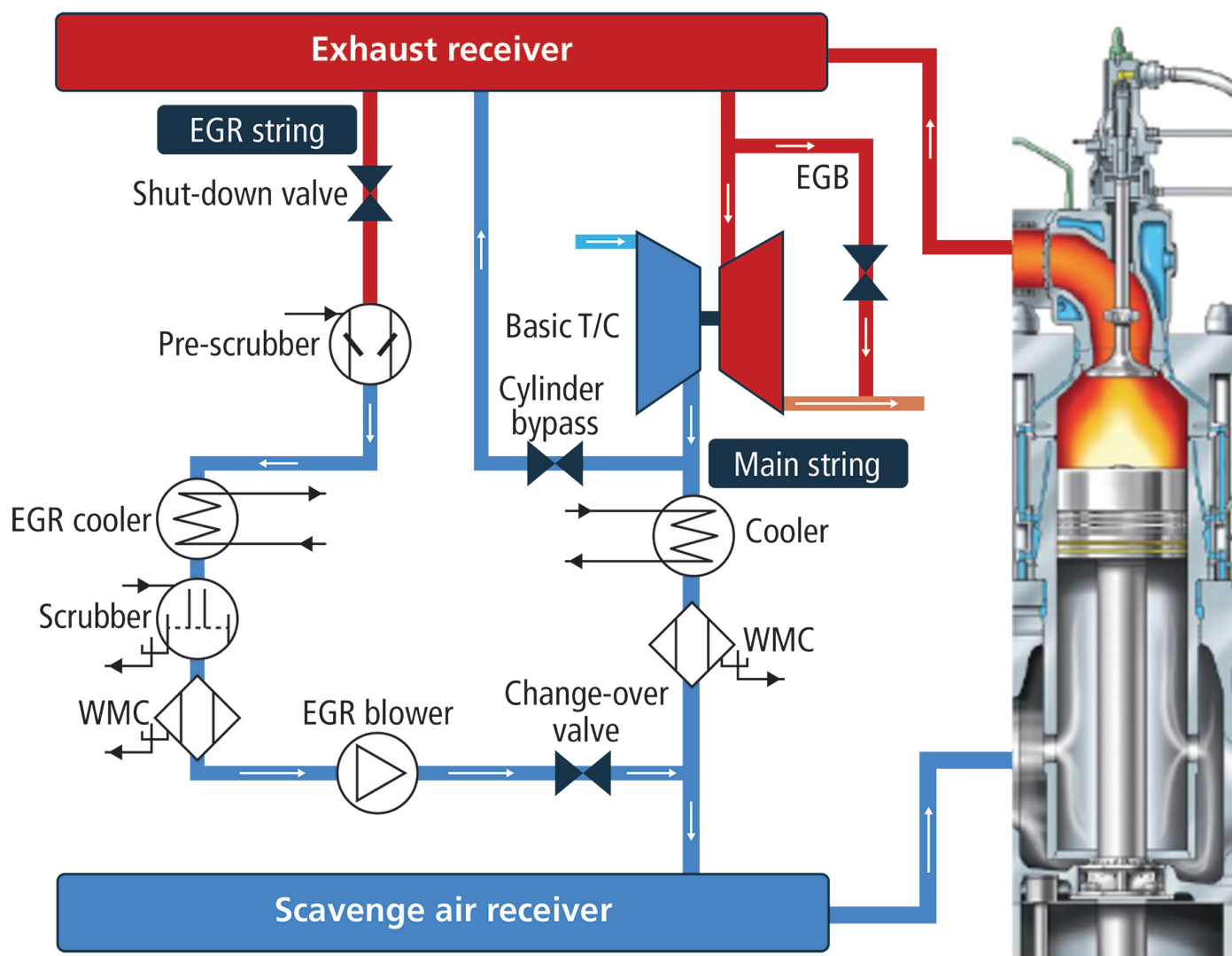
U.S. EPA has additional requirements besides IMO requirements for engines which are to be installed onboard any U.S. flagged vessel. EPA categorizes the marine engines as follows:

- Category 1: Displacement < 7.0 liter/cylinder
- Category 2: Displacement from 7.0 < 30 liter/cylinder
- Category 3: Displacement ≥30 liter/cylinder

Engines intended to be installed onboard U.S. flagged vessels are to comply with the emission requirements laid down in 40 CFR (Code of Federal Regulations) Part 1042 and 40 CFR Part 1043. EPA has four NOx emission Tiers written in Arabic numerals (e.g. Tier 1, 2, 3 & 4) compared to IMO MARPOL which has three emission Tiers written in Roman numerals (e.g. Tier I, II & III).

EPA Tiers are applicable for category 1 & 2 engines only. For category 3 engines the EPA NOx limits are equivalent to IMO Tiers, except that the EPA mandates additional Particulate Matter (PM) measurements during engine certification testing.

U.S. flagged vessels which will be constructed (keel laid) on or after 1 January 2016, if installed with category 1 & 2 engines are to comply with the emission Tiers in accordance with the Tables



Exhaust Gas Recirculation System (Courtesy IMO, MEPC 66/INF.4)

1, 3, 4 of 40 CFR Part 1042.101 and category 3 engines are to comply with the Table 1 of 40 CFR Part 1042.104 which is equivalent to IMO Tier III NOx emission levels.

## NOx Tier III compliance technologies

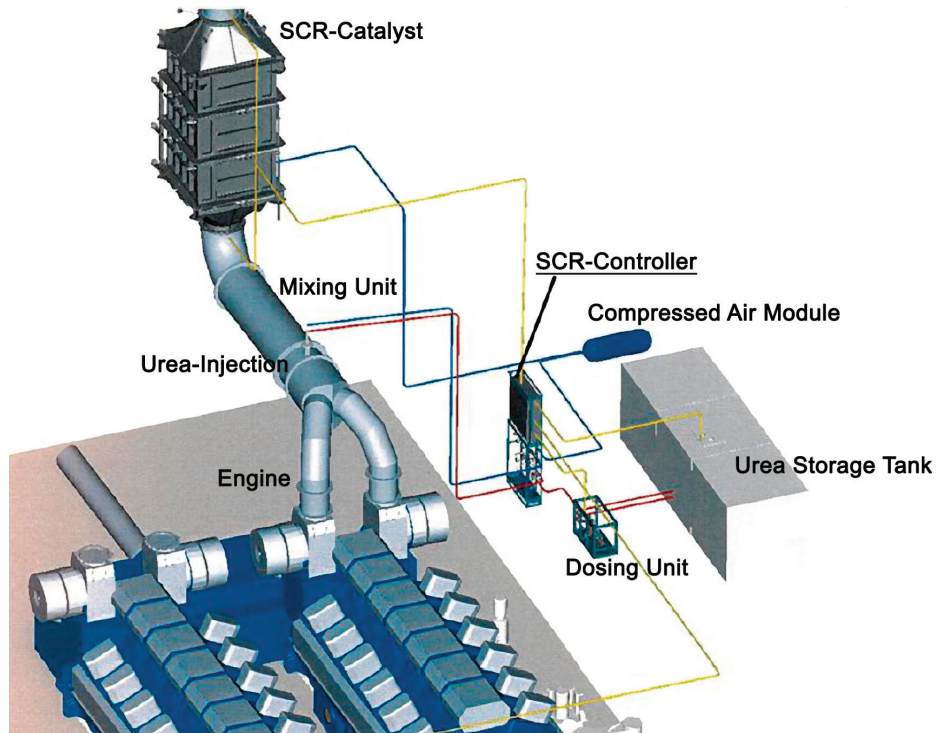
Selective Catalytic Reduction, Exhaust Gas Recirculation as well as the use of Liquefied Natural Gas as a marine fuel are considered the most mature among the available NOx emissions reduction methods.

## Exhaust Gas Recirculation (EGR)

The general principle of EGR system is that 30-40% of the exhaust gas is recirculated to the engine air intake, i.e. the scavenge air receiver. Part of the oxygen in the scavenge air is thereby replaced by CO<sub>2</sub> from the combustion process. This replacement decreases the O<sub>2</sub> content and increases the heat capacity of the scavenge air, thus reducing the temperature peak of the combustion and the formation of NOx. The process requires cooling of the recirculated gas and removal of particulate matter before entering the scavenge air system.

## Selective Catalytic Reduction (SCR)

The SCR process uses a reducing agent to reduce the amount of NOx present in diesel exhaust gas. NOx reacts with aqueous solution of urea, typically 40% urea in water is injected into the exhaust stream before the catalyst. Urea is not defined as a hazardous material, but it has corrosive effects. The urea is decomposed to ammonia before entering the catalyst. Typical urea consumption is about 6.5 g/kWh resulting in about 4.8 kg CO<sub>2</sub>/MWh (increases CO<sub>2</sub> emissions about 1%). The catalyst will lower the activation energy needed for the NOx reducing to N<sub>2</sub> and H<sub>2</sub>O. In order to reach a sufficient reaction rate, and to avoid deactivation and fouling of the catalyst cells, the minimum temperature is typically between 280°C and 340°C while the maximum temperature limit is 400 to 450°C. In low load operation a heater needs to operate in order for exhaust gasses to reach the minimum temperature. Different SCR catalysts,



Selective Catalytic Reduction System (Courtesy IMO, MEPC 66/INF.4)

such as vanadium oxide or metal substituted zeolites of different operating temperature windows, are selected for a particular SCR process. The catalyst elements are normally dimensioned to meet the expected catalyst lifetime of 12,000 to 24,000 running hours. Used SCR elements are treated as hazardous material and have to be handled in line with the local disposal laws.

## Use of Liquefied Natural Gas as a marine fuel

Some vessels installed with dual fuel (gas/liquid) engines may comply with NOx Tier III emission standards in gas mode without using extra NOx control equipment while operating in ECA. On these vessels, some exceptions may apply at times such as immediately after building, before or after dry docking, or when repairs or maintenance are done on board and the ship is required to be in "gas free" condition to meet safety requirements. In such cases, the flag administrations may allow the ship to proceed to or from the shipyard, dry dock, or other maintenance location using liquid fuel, without associated Tier III NOx controls provided the fuel is SOx ECA-compliant. The vessel owners/operators are to get advance approval on this NOx emission non-compliance from the local coastal/port state control.

Questions and requests for assistance can be sent by email to [EnvironmentalPerformance@eagle.org](mailto:EnvironmentalPerformance@eagle.org).