

IMPLEMENTATION OF MARINE SCR SYSTEM TO PRESENT VESSEL TO MEET COMPLIANCE WITH IMO NOX TIER 3 REGULATIONS

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Abstract - As per IMO's 1997 protocol to amend MARPOL 73/78 added Annex VI – Regulations for the Prevention of Air Pollution from Ships. This entered into force on 19 May 2005. Regulation 14 included a 1.50% limit on the sulphur content of fuel to be used in a SO_x Emission Control Area (SECA). Alternatively the use of an approved Exhaust Gas Cleaning System to reduce the total emissions from the ship to an equivalent level of 6g SO_x/kWh was permitted so implementation of exhaust gas cleaning system is mandatory to meet compliance with IMO, it is difficult to change the new Engine on existing vessel to meet the requirement, So providing and SCR system is an alternate system to meet the regulation. Compliance with IMO air emission regulations is a major concern for Ship owners and has considerable operational and commercial impact. For the existing and new build fleets trading to SECA and North America ECA areas a retrofit of the exhaust gas scrubbers, SCR or EGR could be a viable and a cost effective option.

Key Words: IMO NO_x Tier 3 Regulations, Exhaust gas cleaning system, SCR System Implementation, SO_x Emission Control Area (SECA)

1. INTRODUCTION

As per Amendments to MARPOL Annex VI [Resolution MEPC.176 (58)] and amendments to the NO_x Technical Code [Resolution MEPC.177 (58)] were adopted at IMO MEPC 58 on 10 October 2008. All Classifications societies like, DNV, ABS, Class NK will begin NO_x appraisal service relevant to NO_x Tier II requirement on 13 May 2009 prior to the amendments effective date of 1 July 2010. Upon confirmation of compliance with NO_x Tier II requirements by Class, a Statement of Compliance for Engine Air Pollution Prevention may be issued for marine diesel engines.

For your Quick reference, an outline of the principal amendments to Regulation 13 Nitrogen Oxides (NO_x) and Regulation 14 Sulphur Oxides (SO_x) and Particulate Matters would be informed as follows: 1. Outline of the amendments to Regulation 13 Nitrogen Oxides (NO_x) (1) For marine diesel engines (excluding engines to be used solely in case of emergency) with a power output of more than 130kW installed on ships constructed on or after 1 January 2000, or which undergo a major conversion on or after 1 January 2000, the following regulations are to be applied in a 3 tier process.

Tier II and Tier III are newly required in addition to the present requirements of Tier I are follows:

1.1 Tier I

The following NO_x emission limits are to be applied to all marine diesel engines installed on ships constructed on or after 1 January 2000 and prior to 1 January 2011, or which undergo a major conversion on or after 1 January 2000 and prior to 1 January 2011. [Hereinafter, n = rated engine speed (crankshaft revolution per minute)]

- 17.0 g/kWh: When n is less than 130 rpm.
- $45 \cdot n^{(-0.2)}$ g/kWh: When n is 130 or more but less than 2000.
- 9.8 g/kWh: When n is 2000 rpm or more

1.2 Tier II

The following NO_x emission limits are to be applied to all marine diesel engines installed on ships constructed on or after 1 January 2011, or which undergo a major conversion on or after 1 January 2011.

- 14.4 g/kWh: When n is less than 130 rpm.
- $44 \cdot n(-0.23)$ g/kWh: When n is 130 or more but less than 2000.
- 7.7 g/kWh: When n is 2000 rpm or more.

1.3 Tier III

When the ship is operating in Emission Control Areas for NO_x (ECA for NO_x), the following Tier III NO_x emission limits are to be applied to all marine diesel engines installed on ships constructed on or after 1 January 2016, or which undergo a major conversion on or after 1 January 2016.

- 3.4 g/kWh: When n is less than 130 rpm.
- $9 \cdot n(-0.2)$ g/kWh: When n is 130 or more but less than 2000.
- 2.0 g/kWh: When n is 2000 rpm or more.

When the ship is operating outside of an ECA for NO_x, Tier II regulations are to be applied. The ECA for NO_x will be designated by IMO at a later date.

The end of 2018 is fast approaching, bringing with it the deadline for converting to Tier 4 engines for diesel engine users. When the Environmental Protection Agency (EPA) announced the Tier 4 regulations in late 2004, the goal was to cut down on pollutants harmful to the environment. The EPA particularly targeted byproducts known to create pollution.

2. BACKGROUND

Recently 2018, the Environmental Protection Agency (EPA) announced that it finalized regulations implementing emission reductions from large marine diesel engines--so-called Category 3 marine diesel engines--for U.S.-flag vessels. Category 3 engines are marine diesels with per cylinder displacements at or above 30 liters and are mainly used as propulsion engines on large oceangoing vessels such as bulk carriers, cruise ships, tankers, and container ships. In addition, EPA announced that these regulations will implement MARPOL Annex VI, which was signed into law in the United States on July 21, 2008 and which will apply to both U.S. and foreign-flag vessels. Once the Emission Control Area (ECA) proposed by Canada and the United States goes into effect, both U.S. and foreign-flag vessels will have to meet these new standards up to 200 nautical miles off U.S. coasts. EPA's final rule is expected to be published in the near future and will be effective soon after publication. So the current vessel who gets charter to above specified region U.S need to meet the requirement , solution by amending the exhaust gas cleaning system .

3. DESCRIPTION OF EXHAUST GAS CLEANING SYSTEM /SCR SYSTEM IMPLEMENTATION

There are several different designs of marine exhaust gas cleaning systems (often referred to as scrubbers) that remove sulphur oxides from ship's engine and boiler exhaust gases.

However the majority of 'wet' systems have 3 basic components:

- A vessel which enables the exhaust stream from an engine or boiler to be intimately mixed with water – either seawater or freshwater (or both). For reasons of available space and access the exhaust gas cleaning units tend to be high up in the ship in or around the funnel area.
- A treatment plant to remove pollutants from the “wash” water after the scrubbing process.
- Sludge handling facilities – sludge removed by the wash water treatment plant must be retained onboard for disposal ashore and cannot be burned in the ship's incinerators.

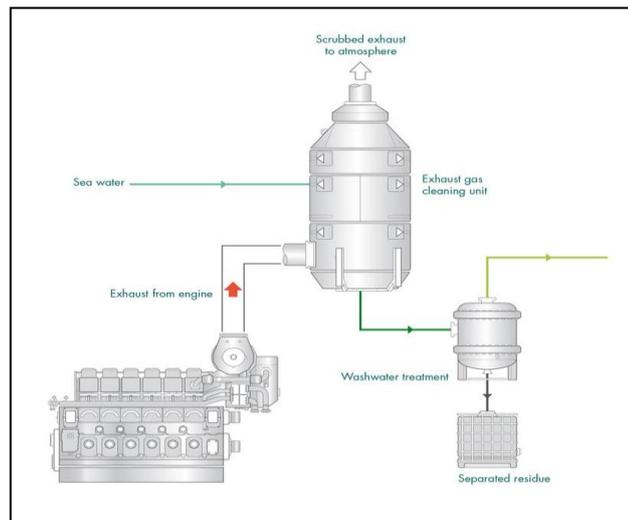


Fig - 1: Exhaust gas cleaning system basic components

The system may be an “open” type, whereby water is taken from the sea, used for scrubbing, treated and discharged back to sea, with the natural chemical composition of the seawater being used to neutralize the results of SO₂ removal. Typically open seawater systems use 45m³/MW h for scrubbing.

The system may be a “closed” type, whereby freshwater treated with an alkaline chemical such as caustic soda is used for neutralization and scrubbing. The wash water is re-circulated and any losses made up with additional freshwater. A small quantity of the wash water is bled off to a treatment plant before discharge to sea. Typically closed freshwater systems have a discharge rate of 0.1- 0.3m³/MW h although the system shown can operate with zero discharge for limited periods.

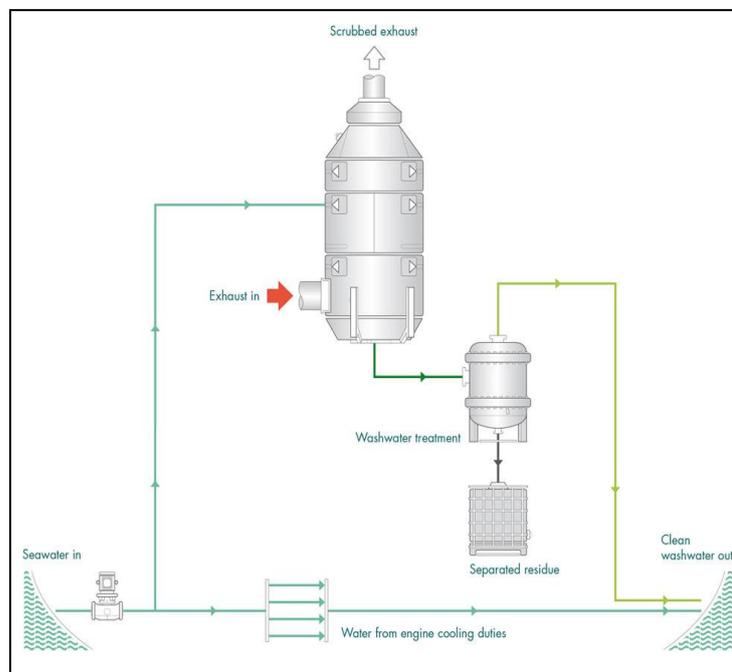


Fig - 2: Open loop exhausts gas cleaning system

Hybrid systems can operate in either open or closed loop mode and depending on design may operate with either freshwater or seawater when in closed loop mode.

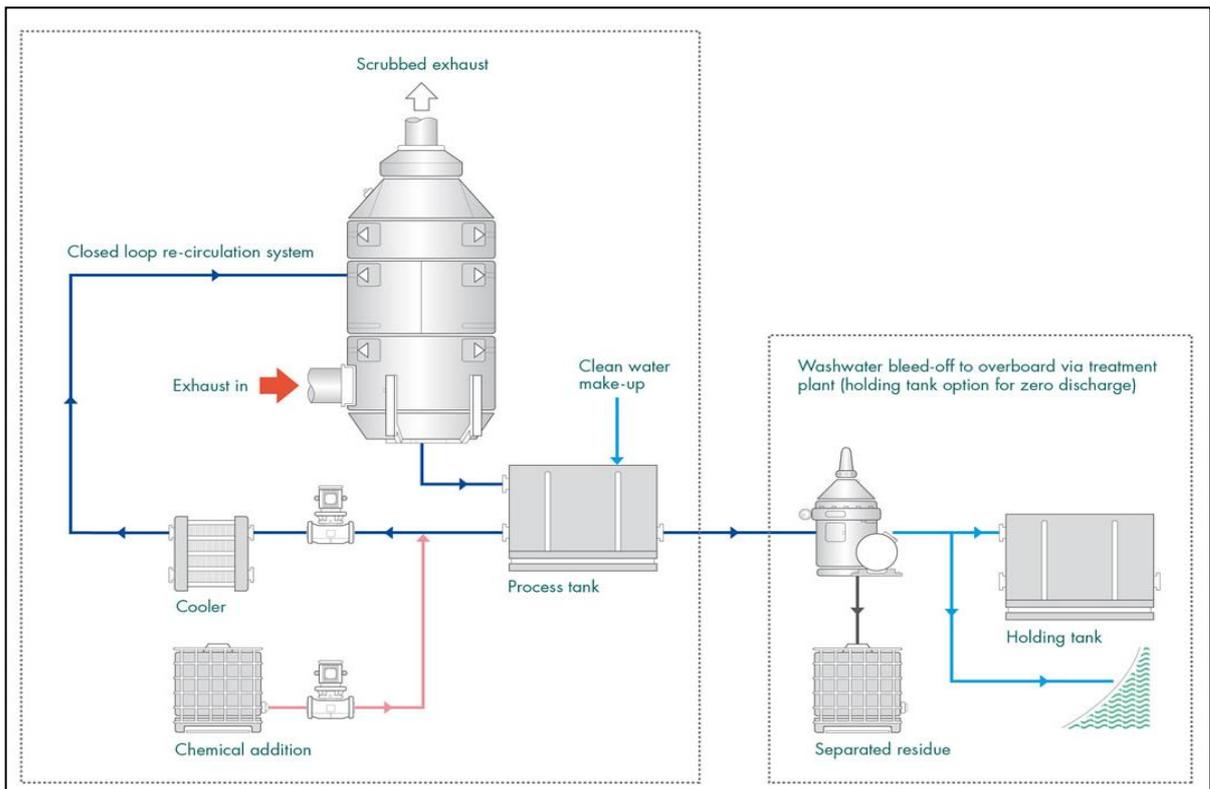


Fig - 3: Closed loop exhaust gas cleaning system

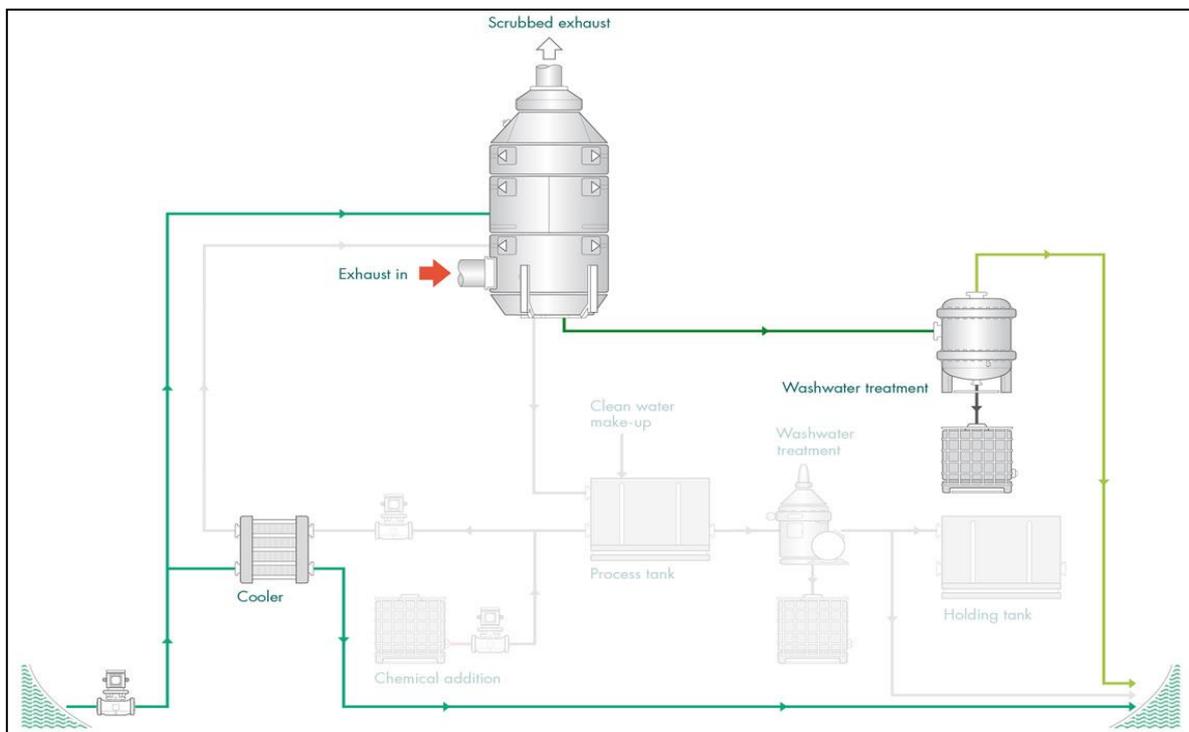


Fig - 4: Hybrid exhaust gas cleaning system open loop operation

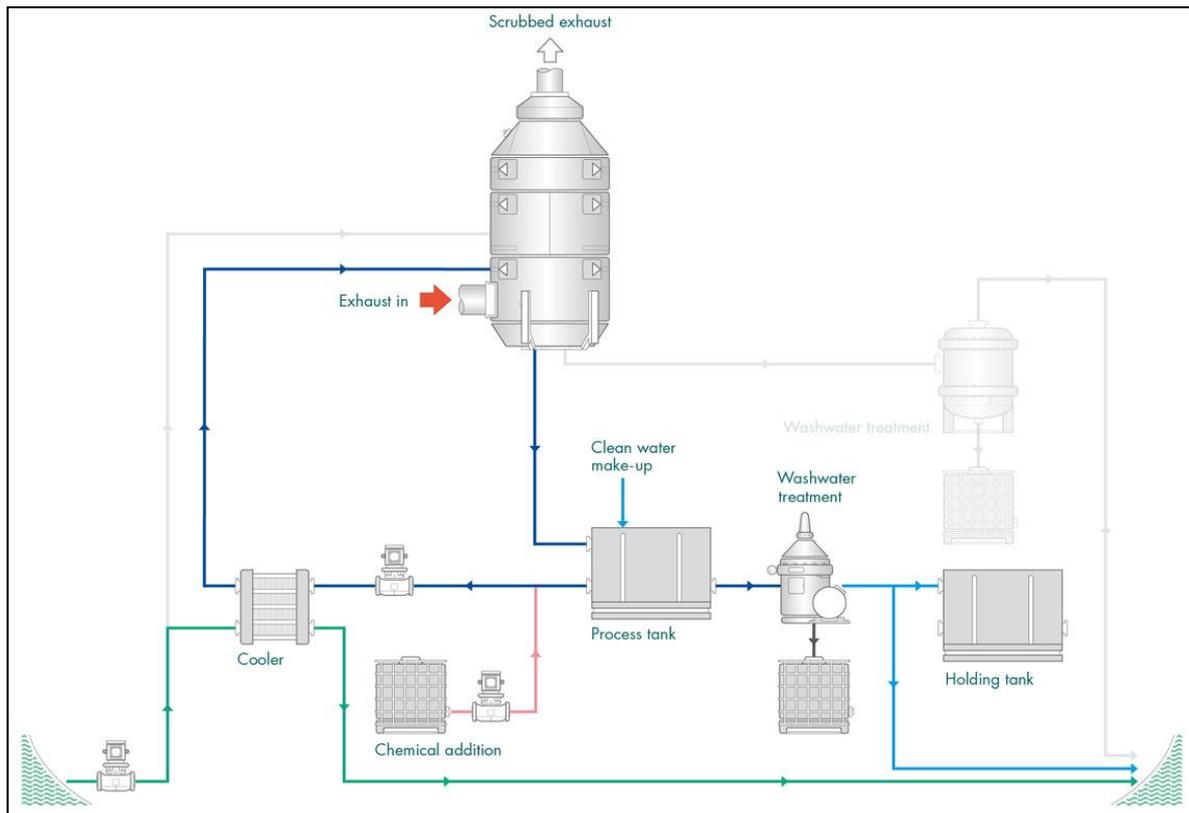


Fig - 5: Hybrid exhaust gas cleaning system closed loop operation

Open ocean alkalinity is usually constant and high at approximately 2200-2300 $\mu\text{mol/l}$. Alkalinity in some coastal areas, ports, rivers and estuaries can be affected by the different drainage areas of the inflowing rivers, resulting in large variations in the chemistry. Rivers running through soil rich in carbonates will be high in alkalinity. For example, the northern rivers of the Baltic Sea run through granite bedrock resulting in low alkalinity at approximately 800-1300 $\mu\text{mol/l}$, whereas the southern rivers run through calcite bedrock resulting in high carbonate concentrations with consequently high alkalinity of approximately 1650 -1950 $\mu\text{mol/l}$. In general, the alkalinity in the Baltic Sea is lower than open sea areas because of the minimal exchange of water through the Danish straits. At low alkalinity levels the seawater scrubber can still operate, but in some cases cleaning efficiency may be reduced. Alkalinity does not refer simply to pH, but to the ability of water to resist changes in pH. Buffering materials are primarily bicarbonate and carbonate, but about 4.0% of the neutralization is provided by borates and other ions in low concentrations. Total alkalinity, is the sum of all these. Salinity describes the salt content of water. The salinity of ocean water is approximately 3.5%-weight. Some waters can have high alkalinity and zero salinity depending on the calcium concentration

It can be confirmed that the alkalinity of water is suitable for scrubbing in an open type exhaust gas cleaning system alkalinity of the sea and harbours open to the sea is typically high and therefore suitable for exhaust gas cleaning. In fact many rivers also have a suitably high alkalinity.

It is not possible to carry out continuous online monitoring of alkalinity with sensors, but it could be checked by chemical titration, which is not entirely practicable onboard ship. Although there is no direct link between salinity and alkalinity or pH and alkalinity, online monitoring of the exhaust gas cleaning system's water supply with pH and salinity sensors is used as a robust indicator of possible issues i.e. a low salinity and/or pH would suggest entry to brackish water.

3.1 PROCESS OF WET IS THE EXHAUST GAS AFTER SCRUBBING

A significant amount of water is produced by the combustion of hydrocarbon fuel oils and we have already seen in the summary of typical emissions from a slow speed 2-stroke diesel engine that the exhaust can contain over 5% water.

So why after an exhaust gas cleaning unit, which would seemingly add water to the exhaust do we not see condensation and a plume above the funnel.

Temperature is a key parameter in determining the mass of water a given quantity of exhaust gas can contain within the exhaust duct i.e. the higher the temperature, the greater the mass of water that can be held before saturation is reached. Between the engine and an EGC unit the exhaust temperature can be approximately 300°C, but after passage through the EGC unit the temperature is reduced very significantly – perhaps by 85% and water in the gas phase is condensed out through contact with the relatively cold washwater.



Fig – 6: Deplume reheater unit

This means the mass of water in a given quantity of exhaust gas can actually be less at exit from an EGC unit when compared with that at entry i.e. water is not necessarily added to the exhaust gas by scrubbing.

Whilst this depends upon the washwater temperature and the actual mass may be reduced, the exhaust gas will be fully saturated when it exits the EGC unit. Typically a demister removes any entrained liquid droplets, and then a re-heater and it is used to raise the temperature so the exhaust is no longer fully saturated. This prevents water in the gas phase forming water vapour and condensing onto cold surfaces. On exit from the funnel into the atmosphere the exhaust gas is immediately diluted, dropping saturation levels. This again prevents any water condensation so a plume cannot form.

4. CONCLUSIONS

The potential environmental impact of exhaust gas cleaning systems using chemicals for scrubbing. For systems, which use “chemicals, additives, preparations or create relevant chemicals in situ” the IMO requires a specific assessment and if necessary the implementation of additional wash water discharge criteria. This can draw on other Guidelines, which require an environmental risk characterization and evaluation process before approval of the substance and system can be granted.

With the implementation of the system It will meet he compliance as per below amendments of Regulation 14 also.

Outline of the amendments to Regulation 14 Sulphur Oxides (SO_x) and Particulate Matters In addition to the requirements for Sulphur Oxides (SO_x), requirements for Particulate Matters have been added. In order to control emission of Sulphur Oxides (SO_x) and Particulate Matters, it is now required that the sulphur content of any fuel oil used onboard ships does not exceed the limits shown in the below table.

Implementation Date	General Requirements	Requirements within ECA for SOx*
(Existing)	4.50 % m/m	1.50 % m/m
On and after 1 July 2010		1.00 % m/m
On and after 1 January 2012	3.50 % m/m	0.10 % m/m
On and after 1 January 2015		
On and after 1 January 2020 *	0.50 % m/m	

* In addition to current SECA (SOx Emission Control Areas), ECA for SOx will be designated by IMO hereafter.

** At 2018, if it is not possible for ships to comply with the requirement from 2020 as a result of a review about the global market supply and demand for fuel oil to comply with the requirement, the requirement shall become effective on 1 January 2025.

The new near-term Tier 2 NOx standards will apply beginning with new engines manufactured in 2011 and generally require the use of more effective in-engine emission reduction technologies. The long-term Tier 3 NOx standards apply beginning in 2016 and generally require the use of after treatment technology, such as selective catalytic reduction (SCR). The NOx emission standard varies with engine RPMs.

	Less than 130 RPM NOx g/kWh	130-2000 RPM NOx g/kWh	Over 2000 RPM NOx g/kWh
Tier 2	14.4	44.0 x RPM (-0.23)	7.7
Tier 3	3.4	9.0 x RPM(-0.20)	2.0

EPA also established a CO emission standard of 5.0 g/kWh and a hydrocarbon (HC) emission standard of 2.0 g/kWh. According to EPA, these emission standards are necessary to prevent increases in CO and HC that might otherwise occur from the application of certain technologies to reduce NOx.

With this process of implementation the major ship-owners can do it an alternate of changing the engines considering avoid a huge investment by implementing this small system to meet the compliance.

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