

The impact of Tier III NOx regulation on the shipping industry

The International Association for Catalytic Control of Ship Emissions to Air (IACCSEA) – The leading global authority on marine SCR technology – explores the operational and cost implications of MEPC 66 on ship owners and operators.

The 66th meeting of the IMO's Marine Environment Protection Committee (MEPC66), which culminated on 4 April in London, agreed a revised course to regulate NOx emissions from shipping.

To summarise the agreement:

- For the existing North American NOx Emission Control Areas (NECA), and the United States Caribbean Sea NECA, Tier III NOx emission standards will apply to marine diesel engines installed on new ships constructed on or after 1 January 2016^{1,2}. As such, all eligible vessels built from 2016, when sailing in the North American or Caribbean Sea NECA, must be Tier III compliant³.
- For any new NECA's which come into force, Tier III NOx emission standards

Table 1

NOx Emission Control Area	Implementation Date of Tier III NOx Standards
North American & US Caribbean Sea	Applies to engines on ships constructed on or after 1 Jan 2016
Future NECA's	Applies to engines on ships constructed on or after the date specified in the amendment designating the future NECA

will apply to marine diesel engines installed on vessels constructed on or after the date of adoption of a new NECA by the Marine Environment Protection Committee, or a later date as may be specified in the application for the new NECA. (see Table 1)

IACCSEA

The International Association for the Catalytic Control of Emissions to Air (IACCSEA) was formed in early 2011. From the outset, the objective of the Association (whose membership includes Yara, Johnson Matthey, Hitachi Zosen, Ibiden, Haldor Topsoe and Cormetech) has been chiefly scientific – namely the demonstration of the technological and economic viability of using catalytic emission control technologies on ships.

As such, IACCSEA has addressed several questions related to the installed base of marine SCR as well as the technical capabilities and costs of the technology.

Installed base of marine SCR technology

The 2012 IMO NOx Review was undertaken by a correspondence group of key stakeholders, including nation states and industry associations. The purpose of the group was to review whether technologies would be available to meet strict NOx limits in time for the proposed 2016 imple-

Figure 1: Total number of vessels with SCR installations

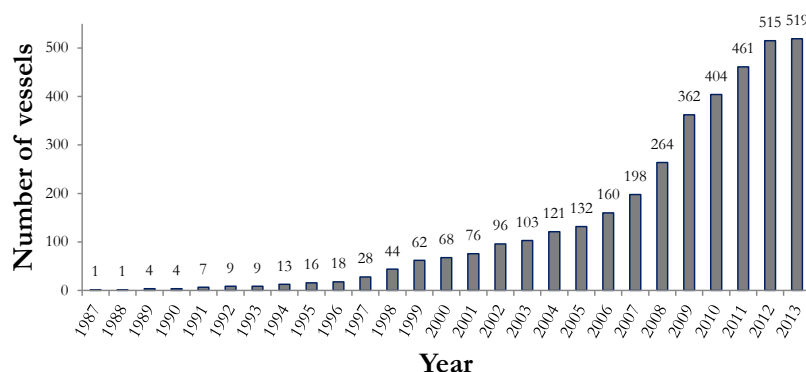
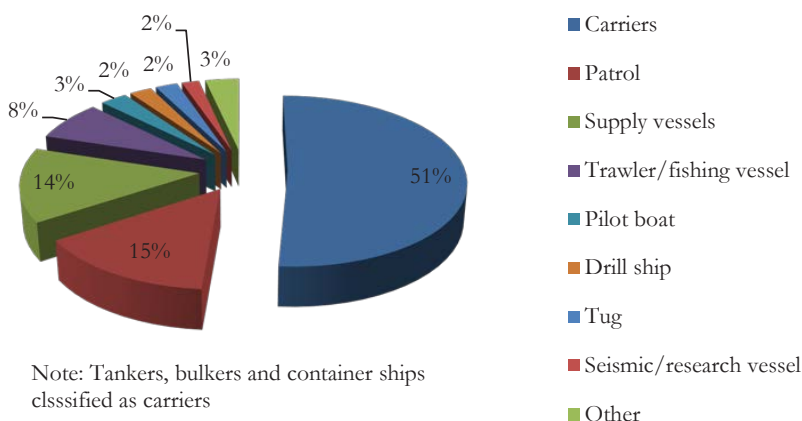


Figure 2: Number of various types of vessels with SCR



mentation date of Tier III NOx regulations. IACCSEA contributed a database of the installed base of marine SCR. The database, compiled using the knowledge and experience of IACCSEA member organisations, accounted for over 90% of SCR experience on marine vessels at the time.

Using the database, it was demonstrated that SCR systems have been installed on over 500 marine vessels over the last 30 years. Some have been in operation for well over 10 years and have accumulated >80,000 hours of experience (see Figures 1 and 2).

Information held within the database also demonstrated how engine manufacturers have applied SCR to a wide range of ship types and engine sizes, utilizing different fuels (of differing sulphur content) and operating over a range of engine conditions.

Cost of marine SCR

In order to grant further insight into the costs and benefits associated with installing and operating SCR technology to meet IMO Tier III NOx limits, IACCSEA developed a first order economic analysis (cost calculation model⁴).

Inputs to the model

The major costs of SCR will depend on engine operation and on the time spent in a NECA. Fixed costs include initial capital and installation costs for the equipment. The major operational costs are those of the reducing agent (e.g. urea). The IACCSEA calculation tool recognises that any fuel penalties which arise due to pressure drop across the SCR system could potentially be offset because a fuel optimised engine with

an SCR system allows for a fuel efficiency benefit.

Critically, the model incorporates some scaling down of costs over the lifetime of the vessel, as it assumes economies of scale. The following is a breakdown of the input considerations:

Capital Cost of the SCR System – The capital cost of SCR technology is mainly a function of the engine power.

Installation Cost – Installation costs are again a function of the engine power, though much lower for new build installation over so-called retrofit.

Maintenance Cost – A maintenance cost of a minimal percentage of capital cost is assumed.

Operating Costs – Operating costs are a function of the time spent in a NECA. The major operating cost is that of the reducing agent, which in the model is assumed to be Urea -

ISO 18611. Other forms of reducing agent such as urea granules or aqueous ammonia are being demonstrated and may offer advantages in certain systems. The cost of replacement catalyst and the fuel penalty due to back pressure exerted by the SCR system can also be considered as operating costs.

Fuel Efficiency – One potential benefit of SCR technology is the fact that engine/SCR systems can potentially be fuel optimised (in the order of a few percent). The calculation tool allows an operator to observe the impact of increased fuel efficiency (accompanied by higher NOx formation in the engine) on the total cost of operation.

Other Costs – Other costs include certification and classification costs. These costs may be significant to begin with but will fall with experience and will become a very small addition to the administration costs, e.g. of certifying the engine.

Output from the model

Table 2 shows two examples of estimated

Table 2

Engine size	10 MW
Vessel weight	20,000 DWT
Time in NECA	1,500 hrs./year
Lifetime ownership cost	EUR 1.3 million or EUR 52k p.a.

Engine size	10 MW
Vessel weight	20,000 DWT
Time in NECA	8,000 hrs./year (whole year)
Lifetime ownership cost	EUR 3.8 million or EUR 155k p.a.

SCR costs derived from the model for a 4T engine with a post turbo SCR. The first is for a vessel that spends 1,500 hours p.a. in a NECA and the second is for a vessel that spends 8,000 hours (the whole year) in a NECA.

Technical capabilities of marine SCR – operation and performance

Most perceived problems and uncertainties surrounding the ability of marine SCR to meet Tier III NOx standards are addressed in the design phase of the combined SCR/engine system. These include reservations related to high sulphur marine fuel, operating under low load, ammonia slip and compatibility with SOx scrubbers.

High sulphur fuel

The global average sulphur content of HFO is currently around 2.4%. Understandably, it is often queried that, as is the case with automotive systems, the high sulphur content of marine fuel will poison marine SCR catalysts. This is not the case. Unlike SCR

catalysts used in the automotive industry, sulphur is not a poison to marine catalysts (which are most often made of vanadium). The key operational consideration for marine SCR systems in high sulphur environments is that specific operating temperatures are required. Tier III NOx limits only apply to new build vessels constructed on or after 1 January 2016. As such, during the design phase of the vessel, SCR providers and engine OEMs collaborate so that appropriate temperatures will be met when the SCR system is in full operation.

Low loads

The relationship between the SCR technology providers and engine OEMs during the design phase of a vessel has evolved to address several other concerns which have historically been raised in relation to the performance of marine SCR technology. The issue of reaching the SCR operating temperature window during slow steaming has been analysed over a period of several years. In order to achieve the suitable heat,

special features to increase exhaust gas temperature have been introduced by engine manufacturers (such as Hitachi Zosen).

Ammonia slip

In order to abate NOx, SCR uses ammonia as the reducing agent (ammonia is a decomposition product of the thermolysis of aqueous urea solution). Once again, during the design phase of an engine/SCR system for a new vessel, catalyst suppliers and engine OEMs will collaborate to ensure that the catalyst is properly sized for the exhaust stream and that there is the correct urea dosage. So long as this work has been undertaken to the correct specifications, over the guaranteed period of the SCR catalyst, there should be no issue with overdosing of urea and subsequent ammonia emissions will be extremely low.

SOx regulations

Ship owners and operators often enquire how 2016 NOx regulations will impact on the technology requirements of 2015 SOx regulations. Again, the question of whether SCR technology is compatible with SOx scrubbers is addressed during the design phase of the engine/SCR system. Vessels built beyond 2016 may choose to fit a scrubber to comply with SOx regulations in conjunction with an SCR system used to comply with NOx standards. The common view is that the SCR system should be positioned upstream of the scrubber and that space should not be an issue as the SCR system is part of the engine and will be integrated when new Tier III compliant vessels are manufactured.

Catalysts and urea

The most frequent questions raised by ship owners and operators in relation to the everyday on board operation and maintenance of marine SCR systems, relate to the catalyst and urea.

Manufacturers guarantee the useful lifetime of the catalyst depending upon parameters such as proposed operating conditions and fuel quality. A useful lifetime for SCR catalysts is often given as 16,000 hours of operation. Particulate matter derived from marine fuel is a factor which often causes SCR catalysts to foul. As such, the lifetime can be extended by the use of dust blowers. The use of a high standard of fuel,



The global average sulphur content of HFO is currently around 2.4%. (Photo: portpictures.nl)

lubricants and urea generally ensures that the engine/SCR functions adequately for many years. When a catalyst's performance deteriorates to the extent that Tier III cannot be achieved, the catalyst is removed and replaced. It is anticipated that this will occur during intervals when the engine is being refurbished.

In terms of on board handling and storage of urea, it is classified as non-toxic non-dangerous goods and is utilised in millions of cars around the globe. The only on board requirement is to fit a venting device for the urea solution storage tank. It is handled and stored in designated tanks/lines/fittings/pumps so to ensure required cleanliness requirements.

Considering urea infrastructure, as per information provided by Yara, land-based SCR applications currently require 20 million tonnes of urea solution per year. The total demand for urea solution in marine applications today is approximately 30 thousand tonnes, or less than 1% of the total land-based use (annual consumptions of urea for a vessel are typically be between 30 - 1000 tonnes, 30 tonnes for smaller fishing vessels and 1000 tonnes for large ferries, cruise ships and big deep sea vessels).

When the Tier III NOx standards become effective, the maritime demand for urea is expected to continue to be relatively small and sufficient quantities of urea will be available for marine applications (as urea will only be required by new vessels operating in NECAs). Marine demand is expected to grow slowly over time as more new vessels and major conversions become subject to the requirements. Urea is produced in over 50 countries and is available across most of the globe. Distribution systems are expected to expand to major ports in response to urea demand for use on ships.

Proof of regulatory compliance with Tier III NOx limits

Tier III compliant "engine plus SCR" systems will be certified by classification societies acting as Recognised Organisations on behalf of the respective Flag State. In this role, the Classification Societies will conduct annual surveys of the technical system verifying compliance. It is expected that port state authorities will have a role in ver-

ifying and ensuring compliant operation – (DNV GL).

Summary

The 66th meeting of the IMO's Marine Environment Protection Committee agreed a revised course to regulate NOx emissions from shipping.

For the existing North American NOx Emission Control Areas and the United States Caribbean Sea NECA, Tier III NOx emission standards will apply to marine diesel engines installed on new ships constructed on or after 1 January 2016. As such, all eligible vessels built from 2016, when sailing in the North American or Caribbean Sea NECAs, must be Tier III compliant. For any new NECAs which come into force, Tier III NOx emission standards will apply to marine diesel engines installed on vessels constructed on or after the date of adoption of a new NECA by the Marine Environment Protection Committee, or a later date as may be specified in the application for the new NECA.

The information presented in this article by IACCSEA demonstrates how, as the shipping industry approaches the 2016 deadline it can draw reassurance from the experience already gained in meeting the tightest of NOx limits. SCR technology has been installed in over 500 vessels. Issues which have been reported have mainly been part of a learning process. Key operational challenges are now resolved thorough holistic thinking, adherence to good practice a more integrated approach involving the engine and its SCR components. IACCSEA has also modelled the costs of marine SCR, so to provide a clearer indication of the cost of compliance for the shipping industry. ■

Notes

¹ Exemptions - Tier III requirements do not apply to a marine diesel engine installed on a ship constructed prior to 1st January 2021 of less than 500 gross tonnage, of 24 m or over in length, which has been specifically designed and is used solely, for recreational purposes.

² NOx control requirements apply to installed marine diesel engines of over 130 kW output power, and different levels (Tiers) of control apply based on the ship construction date. Outside emission



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control areas designated for NOx control, "Tier II" controls, required for marine diesel engines installed on ships constructed on or after 1 January 2011, apply.
³ The resale value of any vessels built after 2016 may be impacted if it does not have Tier III capability.

⁴ In accordance with Competition Law Compliance, the standard practice for data collection from IACCSEA members was followed: A) An attorney specialising in anti-competition law was present; B) Any sensitive information from individual companies (which was required to be >3 months old) was collected by an independent and passed on to a specialist consultant; C) Five companies had to report data for each model input; D) Any sensitive information was aggregated in a manner so that no company could identify any individual company's submission.

Editor's Note: The International Association for Catalytic Control of Ship Emissions to Air (IACCSEA) is the leading global authority on marine SCR technology. For further information, please contact: secretary@iaccsea.com.

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