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CONSIDERATION AND ADOPTION OF AMENDMENTS TO MANDATORY INSTRUMENTS

Comments to the approval at MEPC 65 of amendments to the effective date of the NO_x Tier III standards

Submitted by Canada, Denmark, Germany, Japan and the United States

SUMMARY

Executive summary:	This document provides comments to the technical questions raised in document MEPC 65/4/27 and contains possible amendments to the draft amendments to regulation 13 of MARPOL Annex VI in document MEPC 66/6/3
Strategic direction:	7.3
High-level action:	7.3.2
Planned output:	7.3.2.1
Action to be taken:	Paragraph 43
Related documents:	MEPC 66/6/3; MEPC 65/4/7, MEPC 65/4/8, MEPC 65/4/27, MEPC 65/4/32, MEPC 65/INF.10; MEPC 62/24/Corr.2 and BLG 12/WP.6

Introduction

1 In 2008, the Parties to MARPOL Annex VI unanimously agreed to amend the Annex of the Protocol of 1997 to address growing concerns about the contribution of marine diesel engines to air pollution and its detrimental impacts on human health and the environment. After nearly two years of discussions, the amendments include, among other things, two additional tiers of new engine[1] emission limits for nitrogen oxides (NO_x) based on a regional approach similar to the regulation 14 fuel sulphur limits. The global Tier II NO_x limits reflect a 20% reduction from the Tier I levels originally adopted in 1997, and apply to diesel engines installed on ships constructed on or after 1 January 2011. The regional Tier III NO_x limits are

[1] Engines installed on existing ships are not affected, i.e. retrofitting with NO_x reducing technologies to achieve Tier II or Tier III compliance is not required by the annex except in the case of a major conversion as defined in Regulation 13.2.

more stringent and reflect an 80% reduction from the Tier I levels. These standards solely apply to marine diesel engines installed on new ships constructed on or after 1 January 2016 when operating in a designated NO_x Emission Control Area. Because the technologies that would be used to achieve the Tier III NO_x limits were still under development at the time the amendments were adopted, a review provision was included (regulation 13.10) to verify that engine manufacturers were making progress toward certifying Tier III engines. Establishment of a correspondence group was agreed at MEPC 62. Consistent with regulation 13.10, the review began in July 2011 and was completed in February 2013. The final report, contained in document MEPC 65/4/7, recommended that "The effective date of the Tier III NO_x standards in regulation 13.5.1.1 of MARPOL Annex VI should be retained" (paragraph 13).

2 In document MEPC 65/4/27, the Russian Federation disagreed with the conclusions of the correspondence group. The Russian Federation asserts that the recommendations of the correspondence group are not properly founded, and that the analysis should have focused on the "market availability of the technologies to meet the regulation 13.10 requirements". In addition, the Russian Federation sets out three criteria to be assessed to ensure "that a technology can be considered as sufficient and acceptable internationally". According to the Russian Federation, existing NO_x Tier III technologies do not meet those criteria and, therefore, the effective date of the Tier III NO_x limits should be postponed at least five years. After discussion, but prior to a technical presentation by the Russian Federation, the Committee agreed to consider this proposal to amend the effective date for the NO_x Tier III limits to 2021 for adoption at MEPC 66, with 10 countries reserving their position on the proposed amendments.

3 The co-sponsors are very concerned over this outcome. Postponing the Tier III NO_x limits is not technologically justified, as evidenced by the report of the correspondence group, and will have grave consequences on human health and the environment in currently designated NO_x-ECAs. In addition, the arbitrary nature of such an outcome will likely adversely affect future cooperation of industry stakeholders, including engine and after-treatment manufacturers and shipbuilders of all types, who have in good faith undertaken huge financial investments to develop compliant engines and adapt ship designs to accommodate them and who now see those investments discounted. Further, postponing the standards for five years will also delay the possibility of other coastal states to designate NO_x-ECAs. Finally, postponing these important emission controls risks calling into question the Committee's commitment and ability to addressing the environmental impacts of international shipping and the reliability of standards adopted through coordinated action among states.

4 In the remainder of this document, the co-sponsors briefly answer the technical questions raised in MEPC 65/4/27, which are discussed in more detail in MEPC 65/INF.10.

Background

5 The Committee has long recognized the human health and environmental impacts of NO_x emissions and the need to reduce the contribution of marine diesel engines to these emissions. Annex 1 to this document contains a short summary of these impacts. The Committee took initial action toward reducing these emissions by including standards in MARPOL Annex VI, adopted in 1997. At the time, the Committee acknowledged that the Tier I standards were only a first step and agreed that the NO_x limits would be reviewed at a minimum of five-year intervals after entry into force of the 1997 Protocol to take into account new emission reduction methods. See resolution 3, Review of Nitrogen Oxides Emissions Limitations, adopted by the 1997 MARPOL Conference.

6 The discussions that culminated in the 2008 amendments to MARPOL Annex VI and the adoption of the new NO_x emission standards were lengthy and comprehensive. The Committee agreed to begin these discussions at MEPC 53 in July 2005. The task was assigned to BLG, which began discussions in April 2006. The NO_x control technologies were examined in detail through a correspondence group[2], two intersessional working group meetings (BLG-WGAP 1 and 2), and at BLG 10 (2006), BLG 11 (2007) and BLG 12 (2008). The draft amendments were submitted to MEPC 58, without any bracketed text, where they were adopted by the Committee. It should be noted that from the very beginning of these discussions, it was recognized that Selective Catalytic Reduction (SCR) systems could achieve an 80% or greater reduction in NO_x emissions compared to the Tier I levels (see document BLG 10/WP.3). It was also quickly recognized that, due to the added complexity and costs of high-efficiency advance-technology after-treatment systems, a regional approach would be preferred in which an additional NO_x reduction that would apply to all ships and a larger reduction for ships that operate in specially-designated NO_x emission control areas (see document BLG 11/5/15).

7 There are two relevant points that were raised in the discussions at BLG 12, when the NO_x provisions were finalized. First, as illustrated in the excerpt of the working group report contained in annex 2 to this document, there was broad agreement that an 80% reduction in NO_x emissions from the Tier I standards was technically feasible, although the engine manufacturers would need to address a series of development and production challenges (paragraph 4.7). Second, there was agreement to provide for a technical review to ensure that systems capable of meeting the 80% Tier III standard would be available in 2016. The technical review was thus intended to ensure that technologies would be available, and that the development and production challenges noted by engine manufacturers had been addressed in time for the 2016 effective date of the standards.

8 Following adoption of the 2008 amendments to MARPOL Annex VI, the BLG Sub-Committee continued to work on NO_x-related issues, notably certification procedures for engines equipped with SCR devices. Then, in July 2011, and at the urging of BLG 15, MEPC 62 established a correspondence group to carry out the technical review contained in regulation 13.10. The terms of reference for this group, contained in their final report and reproduced in annex 3 to this document, are very clear: the purpose of this correspondence group is "to review the status of the technological developments to implement the Tier III NO_x emission standard."

9 This technical review was carried out in a timely manner, and its final report was submitted to MEPC 65. The correspondence group noted that technology allowing the implementation of the Tier III NO_x standards is available, and that the effective date of the standards should be retained.

General comments on Russian Federation submittal to MEPC 65

10 In document MEPC 65/4/27, the Russian Federation takes issue with the report of the correspondence group and insists that "the recommendations given in the report on the market availability of technologies to meet the regulation 13.10 requirements are not properly founded". Further, the Russian Federation provides a list of three criteria that must be satisfied if a technology "can be considered as sufficient and acceptable internationally":

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[2] The correspondence group was split into two parts. Group A was to review, among other things, "relevant technologies and potential for reduction of NO_x and recommend future limits of NO_x emissions"; Group B was tasked with, among other things, revisions to the NO_x Technical Code. See documents BLG-WGAP 1/2/1 and BLG-WGAP 1/2/2.

.1 provides for effective nitrogen oxides neutralization in the whole of the interval of the marine diesel engine operation and does not lead to a great amount of side products whose content in the emissions is already regulated by the instruments of the Organization;

.2 does not have an adverse effect on competitiveness of ports and marine transport as a whole; and

.3 only reasonable capital and operational costs are required for its implementation.

11 As a final point, the Russian Federation claims that alternative compliance mechanisms are only briefly described in the report.

12 The co-sponsors are of the view that the second and third criteria advanced by the Russian Federation are influenced by many other factors and for that reason are not applicable to a technology review and were not included in the terms of reference approved by the Committee to guide the development of the report. Specifically, and as explained in greater detail below, the issue of inter-modal shift is not a NO_x technology issue. It is a function of a number of economic issues related to trade and transportation demand for a given country or port. As such, it is a local issue that should be taken up, if at all, in the assessment of an application for NO_x emission control area designation. In addition, costs were considered as part of the discussions leading up to the 2008 amendments to MARPOL Annex VI. These discussions included a range of economic factors from technology demand, raw materials demand and manufacturing costs. As well, costs can decline as technology matures with time, therefore, estimates provide a snapshot of future costs, based on currently understood prices at the time. For these reasons, costs are also required to be considered as part of an application for NO_x emission control area designation along with other economic impacts of ECA designation on shipping engaged in international trade (see MARPOL Annex VI, Appendix III, paragraph 3.1.8.).

13 The remainder of this document provides more detailed discussion of responses to the questions raised by the Russian Federation with regard to three Tier III NO_x technologies: SCR, LNG, and EGR. In addition, information is provided with respect to the expected costs of Tier III technology, based on analysis performed to support designation of the North American Emission Control Area, and on the question of inter-modal shift.

NO_x emission control technology

14 Technologies to achieve the regulation 13 NO_x Tier III limits are now well known and well understood by engine manufacturers. SCR and EGR have been successfully applied to a wide variety of diesel engines, ranging from engines on cars and trucks, to very large non-road engines, and are in current use in vehicles and equipment all over the world. As discussed below, these technologies are applicable to marine engines as well. Natural gas technology is also well understood, although its up-take is more limited due to fuel infrastructure. LNG is becoming more widely available, particularly at ports as the shipping industry realizes the importance of this fuel for land-based cargo handling equipment as well as for ship engines.

15 When Tier II and Tier III NO_x limits were being discussed in 2007, engine manufacturers were already well-enough advanced in their development of the relevant technologies to give detailed presentations and explanations of the challenges they would

meet to resolve in order to deploy compliant engines in the marine sector.[3] Relying on the effective dates as agreed upon in 2008, these manufacturers have invested hundreds of millions of dollars in research and development as well as in production methods to ensure that new marine diesel engines above 130 kW can meet the relevant NO_x limits, and these engines are ready for deployment as planned. For these engine manufacturers, a delay of five years will have important implications as they will not be able to begin to recover these significant research, design, and production costs until at least five years later than anticipated, which will likely have significant impacts on their financial positions.

16 The regulation 13 Tier III NO_x standards begin to apply for engines installed on ships constructed on or after 1 January 2016. In the United States, some domestic NO_x standards have even earlier phase-in dates. Specifically, the comparable standards that apply to diesel engines above 2,000 kW and up to 30 litres per cylinder displacement go into effect in 2014. These standards apply more stringent NO_x limits than the Annex VI Tier III standards and apply to particulate matter (PM) and Hydro Carbon (HC) emissions. All other engines above 600 kW installed on ships flagged or registered in the United States are required to comply with SCR-forcing emission standards beginning with the 2016 model year. Canada has adopted similar requirements for engines with per cylinder displacement above 7 litres. Engine manufacturers are on track to begin certifying engines compliant with these requirements, also indicating that there is no reason to defer the effective date of the MARPOL Annex VI NO_x limits.

17 As a result of all of this research and development, and as described in the following paragraphs, the technical questions raised by Russian Federation are well known, were discussed by the correspondence group and, as reflected in document MEPC 65/4/7, have been addressed by engine manufacturers for engines of all sizes. As a result, no delay in the standards is necessary.

Questions about SCR technology

18 During discussions at MEPC 65, some may have viewed SCR as a technology in the development stage, but in fact, it is already a commercially available technology. SCR has been used in a variety of other industries, such as land-based power plants, incineration facilities, and non-road mobile machinery as well as automobiles for over 30 years. For marine, it is available for 4-stroke and 2-stroke engines, and is applicable for use in any relevant on-board application, e.g. propulsion and auxiliary drives. This has been demonstrated in over 500 ships over the past 20 years, resulting in further development of units with improved efficiency, reliability and endurance. In addition, as noted in document MEPC 65/4/7, Tier III compliant marine engines, equipped with SCR, are already available from multiple manufacturers.

Ammonia slip

19 Regulation 13.5.1 of MARPOL Annex VI requires a 75% reduction in NO_x emissions from Tier II levels. When the SCR catalyst temperature is kept within its normal operating range, these systems are capable of achieving up to 90% NO_x reduction with little to no ammonia slip and would provide up to a 15% margin beyond the Tier III emission standard.

20 SCR controllers limit ammonia slip by design by monitoring the NO_x concentration at the downstream end of the SCR catalyst or the engine conditions (engine speed, load, exhaust gas temperature etc.). The controller adjusts urea dosing based on the amount of NO_x emitted from the catalyst, ensuring that the molar ratio of ammonia to NO_x does not

[3] BLG 12/INF.2

exceed 1.0, which would lead to ammonia slip. Thus, the amount of reductant injected by the SCR system is automatically controlled in real time, ensuring that ammonia slip is kept below 10 ppm.

SCR Temperature

21 NO_x reduction over SCR catalysts typically takes place at temperatures higher than 250ºC. The exhaust gas temperature of 4-stroke engines after the turbocharger turbine usually ranges between 300 to 400°C, providing sufficient activation energy to facilitate the SCR reaction even downstream of the turbocharger. The exhaust temperature at the inlet of the SCR catalyst can be controlled by adjusting the by-pass (or wastegate) to the turbocharger turbine to divert hotter exhaust gas to the catalyst. This allows quick heating of the SCR catalyst during start up and allows precise control of the temperature range during operation.

22 Similarly, 2-stroke engines deliver a typical exhaust gas temperature in the range of 300 to 400°C before the turbocharger, and somewhat cooler after the turbocharger. Technological solutions have been developed to address this issue, including installing the SCR before the turbocharger turbine, reducing the level of charge air, modifying the injection timing, or elevating exhaust temperatures by using burner systems.

23 Maintaining SCR temperature is also important for preventing reaction of ammonia with sulfur compounds in the exhaust resulting in ammonia bisulfate formation. The correlation between the fuel sulfur content and minimum required exhaust temperature to prevent this reaction is widely known and has been published by catalyst- and engine-manufacturers. Further not-to-exceed limits on individual cycle modes have been added to Chapter 3 of the NO_x Technical Code 2008 to ensure that the exhaust gas temperature is sufficient for SCR operation over the certification cycle modes.

CO_2 increase from urea

24 In cases where urea is used as a reductant for SCR, urea is hydrolyzed into ammonia (NH_3) and carbon dioxide (CO_2) over the SCR catalyst as shown in the following chemical equation:

$$(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$$

In this reaction, 0.5 moles of CO_2 is generated for every mole of NH_3. Reduction of NO (NO_x contained in exhaust gas is almost NO) over the SCR catalyst is shown in the following equation:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

In this reaction, 1 mole of NH_3 reduces 1 mole of NO, therefore, 0.5 moles of CO_2 is generated for every mole of NO that is reduced.

25 To give an example of the impact, or lack thereof, of SCR systems on CO_2 emissions, the emission limit of NO_x from the 2-stroke slow speed engine is used, 14.4 g/kWh calculated as total cycle composite weighted emission of NO_2. In order to comply with the NO_x Tier III limit of 3.4 g/kWh, NO_x must be reduced by 11 g/kWh. This equates to 0.24 moles of NO_x (11 g ÷ 46 g/mole = 0.24 moles). During this reduction process, 0.12 moles of CO_2/kWh, or 5.3 g/kWh of CO_2 (0.12 mole × 44 g/mole = 5.3g) is generated.

26 To determine the effect on total CO_2 emissions, the co-sponsors consulted the *2012 Guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships* to provide an example of engine CO_2 emissions. The guidelines provide a Specific Fuel Consumption (SFC) for a main engine as 190 g/kWh and CO_2 emissions per 1 tonne of light fuel oil (LFO) is defined as 3.151 tonnes. Thus the CO_2 emissions from engine itself is 596.7g/kWh. Comparing this to the CO_2 emission contribution from urea (5.3 g/kWh) we find that the urea as a reductant for SCR system contributes less than 1% of the total CO_2 emissions from operation of engine. It should also be noted that this apparent increase in CO_2 emissions is only present when the SCR system is operational in an ECA and in fact may be offset by optimization of the fuel injection timing to maximize fuel efficiency.

Combined use of SO_x scrubber and SCR

27 An exhaust gas cleaning system (EGCS) can be fitted as an alternative to using ECA compliant low-sulphur fuel within a SO_x-ECA. The combination of NO_x-ECAs with SO_x-ECAs will ensure that low-sulphur fuel or EGCS will be used to remove SO_2 from the exhaust stack. Both of these options are viable for meeting the SO_x-ECA requirements and facilitate the use of SCR in a NO_x-ECA. Where an EGCS is employed, this unit may be installed either before or after the SCR unit. If the EGCS, is installed before the SCR unit, then the exhaust would need to be heated prior to the SCR unit to obtain the required reduction in NO_x emissions. If the EGCS is installed after the SCR unit, it will not impact the SCR operation. However, in this case, the SCR unit would be designed for the use of higher sulphur-heavy fuel oils). In any case, any potential for ammonia bisulphate formation will be handled by the SCR controller as described in previous paragraphs.

Urea availability

28 SCR is currently used widely in land-based power plants, incineration facilities, and non-road mobile machinery, as well as automobiles for over 30 years. The reductant (urea) used by these engines is readily available. Today, urea for SCR systems, including for marine applications, is available in the Far East, Middle East, the Americas, Asia and Europe (document MEPC 65/4/7, annex, paragraphs 35 to 41). While there are different types of urea available, this is not an issue. Consistent with known designs, all SCR systems are fully expected to have feedback or feedforward systems in place on the SCR controller to sense changes in NO_x reductions across the SCR catalyst that would require adjustment in urea dosing. These changes could be due to an increase or decrease in urea concentration, or due to catalyst degradation. Therefore, if a ship bunkers with 40.5% urea in water solution, the system would inject less of the solution than if the ship bunkered with 32.5% urea in water solution.

Catalyst availability and disposal

29 SCR catalysts are widely available based on their use in land-based applications. The availability of SCR catalysts can certainly be extended to marine applications, which is evidenced by the current availability of Tier III engines equipped with SCR. Typical catalyst material used in SCR systems are copper-zeolite, iron-zeolite, and vanadium oxides. Vanadium catalysts are known for their sulphur tolerance and are the catalyst of choice for marine applications. Any of these catalysts would be available globally, with the ability of manufacturers and suppliers to ship anywhere in the world. In addition, there are also companies that specialize in making catalysts for use in SCR applications, and these manufacturers can source the materials needed to fabricate and sell their product to meet the demand of the marine market. With regard to replacement, catalysts are expected to be operational for thousands of hours, with replacement occurring at defined intervals that can

be scheduled under normal ship maintenance practices. Therefore, replacement and disposal of catalysts should not be equated with routine operational requirements such as port-side offloading of ship oil sludge or incinerator ash. Finally, disposal requirements are already in place for land-based applications and these provisions can be extended to marine applications.

Questions about EGR Technology

30 Exhaust Gas Recirculation (EGR), like SCR, is a NO_x-reduction technology that has been used in the automotive industry for years. The report from the correspondence group (document MEPC 65/4/7) stated that EGR can be used alone or with other strategies and that more development may be needed to broaden the range of applications. This should not be misconstrued that EGR is not capable of fulfilling the Tier III NO_x limit. In fact, as EGR has been shown to be fully capable of meeting the Tier III limits for at least some applications.[4] At this time, several engine manufacturers are taking orders for two-stroke engines with EGR as the sole NO_x-reducing technology and two EGR engines are in operation. Engines equipped with EGR can run on heavy fuel oil by equipping the engine an EGR-scrubber, which removes sulphate and particulate matter before the exhaust gas is recirculated to the combustion chamber. Thus installation of a SO_x scrubber after an engine equipped with EGR is a fully technically feasible approach to enable a ship to operate on heavy fuel oil in ECAs for compliance with both NO_x and SO_x emission standards.

31 While an EGR system may lead to a small increase in fuel oil consumption depending on engine specifications and fuel type, the application of Tier III limits only in NO_x-ECA's effectively limits any increase in CO_2 emissions.

Questions about LNG

32 Due to the very low NO_x emissions associated with operating on LNG, the use of LNG as marine fuel is another viable option to comply with the Tier III NO_x emission limits. Compared to conventional marine fuel oils, LNG reduces particulate matter and SO_x emissions by almost 100% while NO_x emissions are lowered by 80% to 90%, depending on the engine design. Ship owners that use LNG would benefit from reduced engine maintenance since LNG-fuelled engines produce less soot than diesel-fuelled engines.

33 Although the IMO NO_x Tier III requirements only apply to newly built ships, LNG is not just an option for new buildings but can also be considered for major conversions. Existing engines can be retrofitted for pure gas or dual fuel use. Currently, there are 27 LNG-fuelled ships in operation and 27 more are on order. The infrastructure for fuelling LNG ships is developing with the market, and the number of fuelling stations is growing. In addition a number of leading North European ports have introduced a campaign to promote the use of LNG by establishing LNG bunker facilities. In Canada, there is concerted work by both industry and government to introduce LNG powered ships and LNG bunkering facilities.

[4] See for example Diesel and Gas Turbine World Wide, January-February 2013. Bunkerworld News November 14, 2011. "Tier III EGR FOR LARGE 2-STROKE MAN B&W DIESEL ENGINES", Proceedings of the International Symposium on Marine Engineering (ISME) October 17-21, 2011, Kobe, Japan Paper-ISME586.

Other technologies are emerging

34 It should be noted that other technologies are continuing to emerge to control NO_x emissions. As an example, Canada is presently evaluating a scrubber technology that controls both NO_x and sulphur oxides emissions. Other firms and countries are also developing novel and more efficient emission control systems.

Potential economic impacts of the application of Tier III technology

Questions about competitiveness of ports and marine transport: Intermodal shift

35 Because the study called for under regulation 13.10 of MARPOL Annex VI is a review of technological developments, the terms of reference agreed to at MEPC 62 did not call for analysis of impacts on competitiveness of ports and marine transport (see annex 3 to this document). Intermodal shifts are a function of the choices shippers have to move goods from their origin to their destination, which involves many other considerations, before the selection of a vessel. Instead, the competitiveness of ports is a question that should be reviewed by individual coastal states in their analysis supporting designation of their sea area as a NO_x ECA, as specified in paragraph 3.1.8 of Appendix III to Annex VI, Criteria and procedures for designation of emissions control areas. This will ensure that special regional characteristics of local transportation be taken into account in assessing the likelihood of transportation mode shift. In this way, when a group of coastal states agrees upon the designation of an ECA, there will be a level playing field between those coastal states.

36 The United States Environmental Protection Agency performed a review of nine European studies of the potential impacts of the 2008 MARPOL Annex VI amendments.[5] However, few of these studies examined the separate effects of the NO_x limits on intermodal shift. Overall, however, these and other studies indicate that the potential of a modal shift from sea transport to road or rail transport caused solely by designation of NO_x ECA's (with Tier III only being relevant for new ships) are very small or non-existent. Such an impact would be considered where short sea shipping routes compete directly with road and rail modes. For products and trades that depend on transoceanic shipping, modal shift is not an issue.

Questions about Capital and Operational Costs

37 The review stipulated in regulation 13.10 of MARPOL Annex VI also did not call for additional analysis of capital and operating costs, and the terms of references agreed at MEPC 62 did not include such an analysis (see annex 3 to this document). Capital and operating costs are subject to market changes and also change as technology is commercialized and matures. Instead, costs should be reviewed by individual coastal states in their analysis supporting designation as a NO_x ECA, as specified in the criteria and procedures for designation of emission control areas set out in Appendix III to MARPOL Annex VI.

38 The United States Environmental Protection Agency performed an economic impact analysis of the NO_x Tier III standards on the Category 3[6] marine diesel engine and vessel markets.[7] The engineering cost analysis estimated that the Tier III would cost from about

5 Economic Impacts of the Category 3 Marine Rule on Great Lakes Shipping, EPA-420-R-12.005, April 2012. http://www.epa.gov/otaq/regs/nonroad/marine/ci/420r12005.pdf

6 Category 3 marine diesel engines are those with per cylinder displacement at or above 30 liters.

7 Regulatory Impact Analysis: Control of Air Pollution from Category 3 Marine Diesel Engines, EPA-420-R-09-019, December 2009, Chapter 7 http://www.epa.gov/otaq/regs/nonroad/marine/ci/420r09019.pdf

$367,400 to $678,300 for medium speed engines, and from $605,500 to $2,060,300 for low speed engines, depending on engine size. The analysis was also performed for specific ship types. In the container ship example, the price increase for a ship with a medium speed, 13,900 kW engine is estimated to be about $687,800; this increases to about $1,533,100 for a ship with a slow speed engine, 27,500 kW engine. When compared to a new vessel price of $70 million to $165 million, this represents a 1% to 2% increase in vessel cost. A similar analysis was performed for Category 2[8] marine diesel engines and yielded estimated compliance costs of about $40,000 to $73,000, depending on engine size, compared to new engine prices of $230,000 to $450,000 and new vessel prices of $3 million to $9 million, depending on vessel type.[9] In addition to these capital costs, owners will see an increase in operating costs due to urea consumption. The average dosage of urea for a Category 3 engine is about 7.5% of Brake Specific Fuel Consumption (BSFC); for a Category 2 engine it is about 4%. Further, SCR may for some engine types lead to a small increase in fuel oil consumption, mainly at low loads and highly dependent on the specific engine and on the sulphur content of the fuel. While it is clear that the NO_x Tier III limits will result in additional costs to ship owners, these costs are small when compared to both the total capital and operating cost of a ship and to the substantial human health and welfare benefits that will be achieved from reduced NO_x emissions.

Impacts of delaying the NO_x Tier III limits

39 Through the MARPOL Annex VI ECA designation process, those areas that can demonstrate a need for emission control beyond the global NO_x Tier II limits can achieve additional protection from ship emissions. Delaying the effective date of the Tier III standard for five years despite the availability of suitable NO_x reduction technology will put many people and ecosystems located in already designated NO_x ECAs at additional risk for health and environmental degradation. These areas are counting on emission reductions from a designation that has already been approved. To withdraw these benefits for five years will not only cause harm beginning in 2016, when the standards would otherwise apply, but will result in cumulative harm as the benefits of the programme in 2021 and after will be reduced by those five years of benefits, and those benefits will not be made up until the entire fleet operating in the ECA turns over to Tier III compliant ships. Further, postponing the standards for five years will also delay the possibility of other coastal states to designate NO_x-ECAs. This may force states to take less cost effective measures in other sectors in order to reduce environmental and health risks, or even to take unilateral action with respect to shipping emissions. In this respect, it is not appropriate to delay the effective date of the Tier III standards because of competitiveness of ports or increasing costs.

Conclusion

40 Based on the above discussion, the co-sponsors recommend that the Committee reconsider and deny the circulated amendment to MARPOL Annex VI postponing the effective date of the NO_x Tier III limits. As substantiated by the report of the correspondence group tasked with evaluating the technical developments to implement the Tier III NO_x standards, the relevant emission control technology is clearly available. As noted above, engine manufacturers are already certifying engines of all sizes to these limits. The risks of delaying these standards are great, not just to the reputation of IMO as an international standard setting body, but also to the health and welfare of populations who are depending on these important emission reductions.

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[8] Category 2 marine diesel engines are those with per cylinder displacement from 7 to 30 liters.

[9] Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder, EPA-420-R-08-001, March 2009, Chapter 7 http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2003-0190-0938

41 The co-sponsors also note that consideration of documents MEPC 65/4/8 (ICOMIA and SYBAss) and MEPC 65/4/32 (the Marshall Islands et al.) concerning Tier III NO_x emission standards and its impact on the superyacht sector was set aside as not needing to be considered in light of the Committee's decision at that time to postpone the Tier III implementation date to 2021. The co-sponsors recognize the proposal in MEPC 65/4/32 as a separate issue and would support a sector-specific solution to address the concerns highlighted in these documents, which are the result of the unique vessel design and operating characteristics of these superyachts, including a postponement of the application of the Tier III requirements for these specific vessels, if the effective date of the NO_x Tier III limits is retained as January 2016. Given the gap between the meeting of this Committee when this issue was raised and the effective date of an amendment to Annex VI, and to prevent uncertainty for this sector, an appropriate postponement for these superyacht vessels now would be until 2021. If the Committee agrees with the actions proposed by the co-sponsors to retain the effective date of the NO_x Tier III limits as January 2016, the Committee is requested to give consideration to this issue as a matter of urgency.

42 Annex 4 contains the proposal described in paragraphs 39 and 40.

Action requested of the Committee

43 The Committee is invited to reconsider its decision at MEPC 65 regarding the circulated amendments to MARPOL Annex VI postponing the effective date of the NO_x Tier III limits and retain the existing implementation date of January 2016.

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ANNEX 1

HEALTH AND ENVIRONMENTAL EFFECTS OF NO_X EMISSIONS

1 Ships subject to the North American ECA generate emissions that elevate on-land concentrations of harmful NO_x air pollutants. In addition to ambient concentrations of on-land NO_x, NO_x emissions contribute to on-land concentrations of ozone (as a precursor pollutant) and PM2.5 (formed secondarily as nitrate particles in the atmosphere). This annex contains a brief summary of the human health and environmental impacts of those NO_x emissions. These impacts were acknowledged in the development of the international NO_x emission limits contained in Annex VI, as amended in 2008. Since then, numerous studies continue to confirm these adverse impacts.

2 NO_x is a precursor to ground-level ozone, which is formed by the reaction of volatile organic compounds and NO_x in the atmosphere in the presence of heat and sunlight. Ozone-related health effects include lung function decrements, respiratory symptoms, aggravation of asthma, increased hospital and emergency room visits, increased asthma medication usage, and a variety of other respiratory effects. There is evidence that short-term ozone exposure directly or indirectly contributes to non-accidental and cardiopulmonary-related mortality and is likely to contribute to premature death. Repeated exposures to sufficient concentrations of ozone can also cause inflammation of the lung, impairment of lung defense mechanisms, and possibly irreversible changes in lung structure, which over time could affect premature aging of the lungs and/or the development of chronic respiratory illnesses, such as emphysema and chronic bronchitis. The Technical Support Document prepared in support of the North American Emission Control Area contains a survey of the impacts of NO_x emissions.

3 NO_x is also a source of secondary particulate matter that is formed through atmospheric chemical reactions. Scientific studies show ambient PM is associated with a series of adverse health effects. Health effects associated with short-term exposures (hours to days) to ambient PM include premature mortality, aggravation of heart and lung disease (as indicated by increased hospital admissions and emergency department visits), increased respiratory symptoms including cough and difficulty breathing, changes in lung function, changes in heart rate rhythm, and other more subtle indicators of cardiovascular health[1]. Long-term exposure to $PM_{2.5}$ has also been associated with mortality from cardiopulmonary disease and lung cancer, and effects on the respiratory system such as decreased lung function or increased respiratory disease. Studies examining populations exposed over the long term (one or more years) to different levels of air pollution, including the Harvard Six Cities Study and the American Cancer Society Study, show associations between long-term exposure to ambient $PM_{2.5}$ and both total and cardiopulmonary premature mortality[2,3,4,5,6,7.]

1 U.S. EPA. Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009.

2 Dockery, D.W., C.A. Pope, X.P. Xu, J.D. Spengler, J.H. Ware, M.E. Fay, B.G. Ferris, and F.E. Speizer. 1993. "An Association between Air Pollution and Mortality in Six U.S. Cities." New England Journal of Medicine 329(24):1753-1759.

3 Pope, C.A., III, M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer, and C.W. Heath, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults." American Journal of Respiratory Critical Care Medicine 151:669-674.

4 Krewski, D., R.T. Burnett, M.S. Goldbert, K. Hoover, J. Siemiatycki, M. Jerrett, M. Abrahamowicz, and W.H. White. 2000. "Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality." Special Report to the Health Effects Institute. Cambridge MA. July.

5 Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. 2006. "Reduction in Fine Particulate Air Pollution and Mortality." American Journal of Respiratory and Critical Care Medicine 173:667-672.

In addition, an extension of the American Cancer Society Study shows an association between $PM_{2.5}$ and lung cancer mortality.[8]

4 In addition, exposure to NO_x alone can contribute to adverse health impacts. A broad overview of the health effects associated with NO_2 can be found in the United States Environmental Protection Agency Integrated Science Assessment (ISA) for Nitrogen Oxides.[9] The United States EPA has concluded that the findings of epidemiologic, controlled human exposure and animal toxicological studies provide evidence that is sufficient to infer a likely causal relationship between respiratory effects and short-term NO_2 exposure. The ISA also concludes that the strongest evidence for such a relationship comes from epidemiologic studies of respiratory effects including symptoms, emergency department visits, and hospital admissions. Together, the epidemiologic and experimental data sets form a plausible, consistent, and coherent description of a relationship between NO_2 exposures and an array of adverse health effects that range from the onset of respiratory symptoms to hospital admission.

5 In addition to these significant human health impacts, NO_x emissions have important environmental impacts. NO_x emissions from ships adversely impact sensitive ecosystems across the United States and Canada. These impacts will continue to grow in the coming decades, widely affecting terrestrial and aquatic ecosystems, including areas of natural productivity, critical habitats and areas of cultural and scientific significance throughout the United States and Canada. Adopting the ECA will significantly reduce the annual total sulfur and nitrogen deposition occurring in sensitive United States ecosystems including forests, wetlands, lakes, streams and estuaries.

6 As demonstrated in Annex VI, air quality modeling conducted by the Government of the United States shows that if ships maintain their current emissions performance, by 2020, annual total nitrogen deposition attributable to ships would range from 10% to more than 25% along the entire Atlantic, Gulf of Mexico and Pacific coastal areas of the United States. Of equal significance, ships would contribute to annual total nitrogen deposition in the vast interior and heartland regions of the United States – contributing from 1% to 5% of all deposition in these regions. All these areas contain thousands of terrestrial and aquatic ecosystems which are sensitive to nitrogen deposition and which are adversely impacted by ship emissions.

7 Emissions of NO_x from ships increasingly contribute to the amount of nitrogen being deposited in the United States and Canada. Deposition of certain nitrogen compounds causes acidification, altering biogeochemistry and affecting animal and plant life in terrestrial and aquatic ecosystems across the United States and Canada. Prolonged exposure to excess nitrogen deposition in sensitive areas acidifies lakes, rivers and soils. Increased acidity in surface waters creates inhospitable conditions for biota and affects the abundance and nutritional value of preferred prey species, threatening biodiversity and ecosystem function. Over time, acid deposition also removes essential nutrients from forest soils,

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6 Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi, Y, et al. 2009. "Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality." HEI Research Report, 140, Health Effects Institute, Boston, MA.

7 Lepeule J, Laden F, Dockery D, Schwartz J 2012. "Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up of the Harvard Six Cities Study from 1974 to 2009." Environ Health Perspect. Jul;120(7):965-70.

8 Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution." Journal of the American Medical Association 287:1132-1141.

9 U.S. EPA. Integrated Science Assessment for Oxides of Nitrogen – Health Criteria (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/071, 2008.

depleting the capacity of soils to neutralize future acid loadings and negatively affecting forest sustainability. Major effects include a decline in some forest tree species, such as red spruce and sugar maple; and a loss of biodiversity of fishes, zooplankton and macro invertebrates. The sensitivity of terrestrial and aquatic ecosystems to acidification from nitrogen deposition is predominantly governed by geology. For a fuller understanding of the topics treated here, refer to the extended presentations in the Technical Support Document referenced in the Information Document that accompanied the North American ECA application.

8 The contribution of international shipping to national NO_x emission inventories can be significant. For example, it is expected that by 2020, NO_x emissions from shipping will exceed all other sources of NO_x in the European Union, in part because shipping emissions are expected to continue to increase without further NO_x controls.[10] In the United States, international shipping contributes 12% of the total national NO_x inventory, and 24% of the mobile source NO_x inventory.[11] These emissions are from engines of all sizes on ships engaged in international marine transportation, ranging from small (130 kW) generators to large (>50,000 kW) propulsion engines.

9 Currently, there are only two areas that are designated as NO_x emission control areas: the North American ECA and the United States Caribbean Sea ECA. As part of the North American ECA package, the United States performed air quality and benefits modeling for the entire ECA program, including the fuel sulfur limits and the Tier III NO_x limits. Since the fuel sulfur limits primarily control SO_2 emissions and directly emitted PM2.5, the NO_x reductions estimated in 2020 are associated with the NO_x limits. As described above, NO_x emissions contribute to both ambient concentrations of PM2.5 (formed secondarily as nitrate particles in the atmosphere) and ozone (as a precursor, along with VOCs). Because the analysis estimated the health impacts of the entire ECA program, it is difficult to parse out the exact impacts related to each component of the program. That said, since NO_x emission reductions are only associated with the NO_x limits, we can attribute all ozone-related health benefits from the ECA program to the Tier III NO_x limits. By 2020 in the United States, after only five years, the NO_x limits are expected to yield significant ozone-related benefits, including the annual avoidance of as many as 280 premature deaths, 1,100 hospital admissions and emergency room visits, 1,300 days of school absence, and 360,000 days of restricted physical activity. Note that by reporting the ozone-related benefits alone, we underestimate the total benefits of the NO_x limits because we are unable to separately account for the PM-related benefits associated with NO_x emission reductions.

10 In Canada, significant health benefits also are expected from reductions in NO_x emissions with the North American ECA that stem from reductions in ozone. The implementation in 2016 of Tier III NO_x limits for marine vessels is expected to result by 2020 in the annual avoidance of 12 premature deaths, 55 hospital admissions and emergency room visits, 21,000 days of restricted physical activity, and 85,000 asthma and respiratory symptom days. A delay in the implementation of these standards will also minimize the ozone-related benefits of the North American ECA NO_x standards, as indicated in table 1. As the Tier III NO_x standards will also contribute to reductions of secondary PM 2.5, the health benefits may be greater than the ozone-related benefits indicated below.

11 As indicated in the North American ECA package, there are substantial environmental benefits to be gained from reduced nitrogen deposition as a result from implementation of the Tier III NO_x standards in 2016. Nitrogen deposition contributes to

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10 See http://ec.europa.eu/transport/modes/maritime/events/doc/2011_06_01_stakeholder-event/item4.pdf

11 See Proposal to Designate North American as an Emission Control Area for Nitrogen Oxides, Sulphur Oxides and Particulate Matter (MEPC 59/6/5)

acidification, altering biogeochemistry and affecting animal and plant life in terrestrial and aquatic ecosystems. If ships were to maintain their current emissions performance through to 2020, ships would continue to make significant contributions to nitrogen deposition in Canada on a regional basis. In particular, ship emissions would contribute up to 60% of total nitrogen deposition in the southwest coast of British Columbia and up to 15% in the remaining coastal areas. Overall in Canada, reductions in total nitrogen deposition of up to 15% by 2020 would be expected as a result of the implementation of the Tier III NO_x standards in 2016. As well, the ECA standards would eliminate excess deposition over an area of around 13, 500 km^2 across Canada.

Table 1. Expected health benefits in 2020 of the ECA and ozone related benefits arising from implementing Tier III NO_x standards in 2016

Canada	Total ECA benefits*	Ozone-related benefits**
Mortalities	175	12
Hospital Admissions	34	11
Emergency Room Visits	95	44
Adult Chronic Bronchitis Cases	136	0
Child Acute Bronchitis Episodes	782	0
Asthma Symptom Days	18,800	12,400
Minor Restricted Activity Days	21,100	21,100
Restricted Activity Days	151,000	0
Acute Respiratory Symptom Days	288,000	73,500

* Resulting from reductions in ambient PM and ozone
**Resulting from reductions in ambient ozone

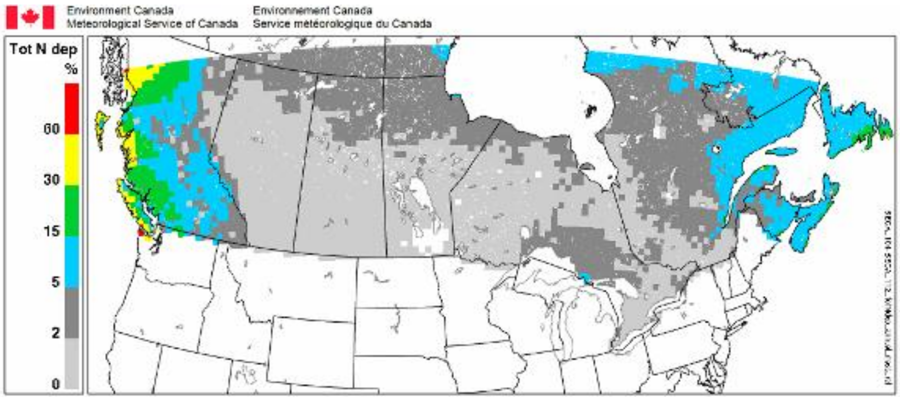

Figure 1. Ships' Contribution to nitrogen deposition in 2020 without implementation Tier III NO_x standards

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ANNEX 2

EXCERPTS FROM DOCUMENT BLG 12/WP.6

Review of MARPOL Annex VI and the NO_x Technical Code

"4.6 A number of delegations expressed the view that a geographically based approach that requires significant reductions in Emission Control Areas (ECAs), should be introduced as this approach provided a global framework for reducing NO_x emissions in coastal areas with the most severe problems while allowing operation at the Tier II level outside Emission Control Areas. It was also noted that this approach would offer significant protection of the environment and human health while avoiding increased fuel consumption that is associated with less advanced NO_x reduction technologies.

4.7 Some delegations noted that while they had supported the 40 to 50% reduction option in previous discussions, recognizing the need of some regions to achieve more stringent reductions has led them to support an 80% reduction in Emission Control Areas. The United States also noted that while they had proposed a reduction of 83 to 87% from Tier I levels, they could support an 80% reduction as discussed by the working group. EUROMOT noted that advanced treatment systems have been used in marine applications and that while the engine manufacturers would need to address a series of development and production challenges, the 80% Tier III standard was technically feasible. EUROMOT further noted that it was important to establish a clear standard and date of implementation for Tier III to facilitate the necessary planning and production development. The group noted that engine manufacturers in Japan are currently conducting development and refinement of advanced engine treatment systems to meet the proposed Tier III standard.

4.8 Following further discussion in the working group, the group unanimously agreed to support a Tier II reduction as proposed by China (outlined in paragraph 4.4) and a Tier III reduction of 80% from Tier I applicable to new builds beginning on 1 January 2016 in specific emission control areas designated through the Organization. As such, the Tier III limits will apply in designated areas but not in coastal areas defined by a fixed distance around the globe.

4.9 ICS supported by a number of delegates further recommended that it would be prudent to include a provision in the amended Annex to provide for a technical review to ensure that systems capable of meeting the 80% Tier III standard will be available in 2016. Norway also supported by a number of delegations, expressed the view that such a review clause could mean that the engine manufacturers would not have the incentive to undertake the necessary development if such a clause was included in the amended Annex VI, but agreed to include in the draft proposal for final decision by MEPC. The working group agreed to include such a provision whose text is set out in draft paragraph of the draft amended Annex VI set out in annex 1 to this report."

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ANNEX 3

EXCERPTS FROM DOCUMENT MEPC 62/24/CORR.2

Terms of Reference for the Correspondence Group to Review the status of the technological developments to implement the Tier III NO_x emission standard

"4.24 The Committee agreed to establish a correspondence group under the coordination of the United States[1], rather than an expert group, to review the status of the technological developments to implement the Tier III NO_x emissions standard with the following Terms of Reference:

1 The Correspondence Group (NO_x-CG) is instructed to review the status of technological developments to implement the Tier III NO_x emissions standards as required under regulation 13.10 of MARPOL Annex VI and shall:

.1 consider the matter, including deliberation of what information and data are pertinent for the review and how that information and data should be collated and analyzed;

.2 using this data and any other information, consider the status of technological developments to implement the standards set forth in regulation 13.5.1.1 of MARPOL Annex VI, with a view to reporting on the following:

  .1 range of technologies (engine fitting, material, appliance, apparatus, other procedures, alternative fuels or compliance methods) that may be used to comply with the Tier III NO_x standards;

  .2 the current use of these technologies on marine diesel vessels with a view towards characterizing the introduction and demonstration of these technologies in real world applications;

  .3 progress of engine and after-treatment manufacturers towards developing such technology and expectations for bringing Tier III NO_x technologies fully to market by 2016;

  .4 identification of any sub-sets of marine diesel engines where there will not be technologies available to comply with the Tier III standards;

  .5 where relevant, the global availability of consumable products used by a certain technology to reduce emissions to the required standard in Tier III, including supply chain issues, e.g. restrictions on import, export and sale;

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.3 recommend whether the effective date in regulation 13.5.1.1 of MARPOL Annex VI should be retained or, if adjustment is needed, reasoning behind that adjustment; and

.4 provide an interim report to MEPC 64 and submit a final report to MEPC 65 in 2013."

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ANNEX 4

DRAFT AMENDMENTS TO MARPOL ANNEX VI

Amendments to the approved draft amendments of regulation 13 of MARPOL Annex VI contained in the annex to MEPC 66/6/3

1 Regulation 13.2.2 is amended as follows:

"2.2 For a major conversion involving the replacement of a marine diesel engine with a non-identical marine diesel engine or the installation of an additional marine diesel engine, the standards in this regulation in force at the time of the replacement or addition of the engine shall apply. On or after [1 January 2021] for a marine diesel engine specified in paragraph 5.2.3 of this regulation, and on or 1 January 2016 for other engines, in the case of replacement engines only, if it is not possible for such a replacement engine to meet the standards set forth in paragraph 5.1.1 of this regulation (Tier III), then that replacement engine shall meet the standards set forth in paragraph 4 of this regulation (Tier II). Guidelines are to be developed by the Organization to set forth the criteria of when it is not possible for a replacement engine to meet the standards in paragraph 5.1.1 of this regulation."

2 Regulation 13.5.1 is amended as follows:

"5.1 Subject to regulation 3 of this annex, the operation of a marine diesel engine that is installed on a ship constructed on or after 1 January ~~2021~~2016:"

3 A new subparagraph 5.2.3 is added as follows:

".3 a marine diesel engine installed on a ship constructed prior to [1 January 2021] of less than 500 gross tonnage, with a length (L), as defined in regulation 1.19 of Annex I to the present convention, of 24 m or over when it has been specifically designed and is used solely, for recreational purposes."