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CONSIDERATION IMPROVED AND NEW TECHNOLOGIES APPROVED FOR BALLAST WATER MANAGEMENT SYSTEMS AND REDUCTION OF ATMOSPHERIC POLLUTION

Consideration of equivalent technologies for reduction of sulphur oxides (SO_x)

Submitted by the Institute of Marine Engineering, Science and Technology (IMarEST)

SUMMARY

Executive summary:	This document provides an overview of technologies that may achieve at least as effective sulphur oxide (SO_x) emission reductions as low sulphur marine fuel. The document also introduces a clearing house for information by the International Council on Clean Transportation (ICCT) that will continue to provide updated state-of-the-art data on such technologies. This initial review of available technologies suggests that there are several different exhaust treatment and alternative fuel technologies that offer the potential for 80 per cent or greater SO_x emission reduction. The information repository will be publically available and include information on the technologies' emission reduction potential, installations, technical and policy barriers to using these measures, and technology providers.
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1
Action to be taken:	Paragraph 21
Related documents:	MEPC.184(59); MEPC 62/4/10, MEPC 62/4/16 and MEPC 62/4/18

Background

1 Regulation 14 of the revised MARPOL Annex VI sets caps on sulphur content of fuel oil in 2015 and 2020 as a measure to control sulphur oxide (SO_x) emissions. The sulphur content of any fuel oil used on board ships shall not exceed 3.50 per cent on and after 1 January 2012, and 0.50 per cent on and after 1 January 2020, subject to a review in 2018, and may be postponed to 2025. Ships operated within an Emission Control Area (ECA) shall use fuel oil with sulphur content not exceeding 1.00 per cent on and after 1 July 2010 and 0.10 per cent on and after 1 January 2015.

2 MARPOL Annex VI also includes regulation 4 on "Equivalents" enabling Administrations to allow any fitting, material, appliance or apparatus to be fitted in a ship or other procedures (e.g. alternative fuel oils) used as alternatives to comply with the low sulphur marine fuel requirements in MARPOL Annex VI, if the equivalent measures are at least as effective in terms of their associated SO_x emission reduction. Guidelines relating to equivalent measures have also been adopted, for example, 2009 guidelines for exhaust gas cleaning systems (resolution MEPC.184(59)).

3 There is increasing discussion on the equivalent measures, as the date to switch to 0.1 per cent fuel in ECAs approaches. Industry, policymakers, and other stakeholders are interested in whether and which equivalent measures are technically and practicably feasible to reduce demand for compliant low sulphur fuel oil and achieve the same SO_x emission reductions. However, data from different technologies are often lacking or of limited rigour, in disparate places, and/or prone to misinterpretation – and these factors can make technical comparisons difficult. To help fill the data gap and reduce potential misconceptions related to equivalent technologies, the International Council on Clean Transportation (ICCT), in collaboration with the Institute of Marine Engineering, Science and Technology (IMarEST), has compiled a database for information on the various equivalent technologies. The database will be maintained and updated regularly. The database is designed to facilitate technical comparisons and a meaningful data-driven discussion on equivalent technologies.

Equivalent technologies

4 The ICCT has conducted a comprehensive survey of existing scientific literature and technology providers regarding potential technologies and their abilities to reduce SO_x emission. Eleven major technologies have been reviewed. Two of them, exhaust gas cleaning systems and alternative fuel, can achieve similar SO_x reduction to 0.5 per cent or 0.1 per cent sulphur fuel. The database can be downloaded for free at the ICCT website[1]. The ICCT invites information and comments as the ICCT continues to update the database. The following is a brief introduction of the technologies within two major equivalent technology areas (i.e. exhaust gas cleaning, and alternative fuels), their emission reduction potential, and limitations.

Exhaust gas cleaning systems

5 Primarily used to desulphurize exhaust gases from power generation, exhaust gas cleaning systems have become relatively mature for marine application, with more than 30 commercial installations. The exhaust gas cleaning systems typically reduce SO_x by 80 per cent to 99 per cent. Some scrubbers, primarily dry scrubbing systems, can also reduce NO_x by up to 60 per cent. The influence on fuel consumption and CO_2 emission is uncertain, with some claims of at least a 15 per cent CO_2 emission reduction and other research showing about a 4 per cent increase in CO_2 emission. The CO_2 emission reduction is due to the absorption of CO_2 in water and the increase can be attributable to the increased energy consumption or the release of CO_2 from seawater after the addition of acids. The exhaust gas cleaning systems now include open loop wet scrubbers, closed loop wet scrubbers, hybrid wet scrubbers, and dry scrubbing systems.

.1 *Open loop wet scrubbers* clean the exhaust gas using seawater, which is physically treated to remove sludge and then discharged overboard. The sludge has to be disposed of at port reception facilities. This system

[1] International Council on Clean Transportation "The Arctic, maritime shipping, and black carbon"; http://theicct.org/sites/default/files/ICCT_Emissions_Control_Strategies.xlsx.

requires the least amount of space, but the chemical composition of seawater, especially alkalinity, can affect performance and its use can be restricted in environmentally sensitive regions. Some ports, such as the Port of Los Angeles, prohibit discharge of scrubber effluent overboard unless operators show that the effluent complies with criteria set by the port or the port State. Our review indicates that these technologies can deliver an 80 per cent reduction in SO_X emission with 1 per cent to 2 per cent fuel consumption penalty.

.2 *Closed loop wet scrubbers* share the operating principle of the open loop scrubbers but draw freshwater from onboard tanks instead of seawater. Water that has been used to scrub exhaust gases is chemically treated with caustic soda, separated from the sludge, and then recirculated. Major additional components include freshwater tanks and caustic soda storage. These components add space constraints and lead to extra cost of handling and training, as well as operation. These systems can achieve an approximate 95 per cent SO_x emission reduction with a 0.5 per cent to 1 per cent fuel consumption penalty.

.3 *Hybrid wet scrubbers* incorporate the components of both the open- and closed-loop systems, offering the choice of operation based on the surrounding water quality and local discharge restrictions. The Hybrid wet scrubbers can achieve about 90% of SO_x emission reduction, with about 0.5 per cent to 2 per cent fuel consumption penalty.

.4 *Dry scrubbing systems* depend on dry bulk reactants for treatment of the exhaust gas. The systems use calcium hydroxide in the form of spherical pellets that are fed to a dry reactor where the engine exhaust gas passes. The SO_x compounds react with the pellets and produce gypsum ($CaSO_4$) and water, which are then removed by a discharge conveyor for storage and offloading. The gypsum is 1.5 times heavier than the calcium hydroxide and contains all pollutants from the exhaust gas; mainly soot, PAH, heavy metals and uncombusted fuel oil. Our review indicates that about a 98 per cent SO_x reduction is achievable with a 0.15 per cent to 2 per cent fuel consumption penalty.

6 These scrubber systems also share some common limitations. The single biggest barrier for the use of scrubbers is the installation cost, compounded by uncertainty of the continued availability of heavy fuel oil (HFO). Additionally, there are concerns related to the available space within engine room (especially for the funnel area), corrosion of inert gas scrubbers, the ability to integrate scrubber and selective catalytic reduction (SCR), and associated damage to piping systems.

7 Policy-makers and technology providers are working to address these limitations. Some guidelines developed by major ports should be helpful in addressing some of these concerns. The EU, for example, indicated that they would develop criteria for addressing waste streams in their ports. That will help technology providers and shipowners to have greater certainty about the prevailing regulations and also reduce compliance cost. New types of scrubbers are designed to replace standard silencers, which would reduce the extra engine room space required. Some providers are also testing how to combine the scrubber and the SCR, so that new-built ships can comply with Tier III standards and the low sulphur fuel standard, potentially without requiring the use of compliant low sulphur fuel.

Alternative fuel

8 The alternative fuel categories that are most associated with marine vessels are liquefied natural gas (LNG) and biodiesel. LNG is natural gas that is converted to liquefied form. When cooled and liquefied, the volume is decreased substantially as compared to the gas. Like scrubber technology, LNG and biodiesel both have much wider usage in land applications aimed at reducing emissions from stationary sources and from vehicle fleets. Because LNG and biodiesel (from most typical sources) do not have any significant sulphur content, the use of these alternative fuels can essentially eliminate SO_x emissions.

LNG

9 Compared with conventional marine fuels, LNG has a number of advantages. LNG can eliminate almost all SO_x and PM emission. The use of LNG as a replacement of marine fuel oil can also help ships achieve compliance with Tier III NO_x standards, reducing NO_x emission by 80 per cent. The exhaust CO_2 reduction from LNG offers about a 20 per cent to 30 per cent reduction due to its lower fuel carbon intensity per energy unit. However, methane leakage and other upstream fuel processes affect the overall life-cycle outcome of LNG, and the science is evolving in this area. Additionally, the price of LNG has been slightly lower than HFO on an energy-equivalent basis historically, but has dropped to approximately half of that of HFO in 2010 and 2011.

10 Two types of natural gas engines have been developed to accommodate the use of LNG as a marine fuel. They are spark-ignited lean-burn and dual-fuel diesel pilot ignition with gas injection.

11 The spark-ignited lean-burn gas engine allows gas to be mixed with air before the inlet valves. During the intake process, natural gas is fed into a prechamber. During the compression phase, the gas/air mixture in the prechamber is ignited by a spark plug. The flames from the nozzle of the prechamber ignite the gas/air mixture in the whole cylinder. After the working phase, the cylinder is emptied of exhaust and the process starts again.

12 The dual-fuel diesel pilot ignition engine also uses the lean-burn combustion process when ships are operating on gas. To assist with ignition, a small amount of fuel oil, serving as a pilot, is injected into the engine cylinder followed by the main natural gas fuel injection. Ships with duel-fuel engines are also equipped with a backup fuel system. The engine is able to transfer from gas mode to fuel oil operation mode instantaneously and automatically. The development of the dual-fuel engine is to alleviate concerns for LNG availability in different ports.

13 So far, LNG use in ships has been limited to a few ferries and LNG supply vessels due to issues related to the engine retrofit costs, fuel storage requirements, safety concerns, and infrastructure constraints for ships and bunkering facilities. Market penetration will also be dependent upon whether the price of LNG will remain as low as HFO.

14 In response to these bunkering constraints, a number of in-development projects are underway. A number of countries and ports are drafting plans to promote LNG as a viable marine fuel. For example, the ports of Rotterdam and Gothenburg have committed funding to build LNG bunking terminals with target date for completion by the end of 2014 and 2015, respectively. With these port infrastructure commitments, the prospects for expanded LNG bunkering in the future, and the substantial cost advantage of LNG, some dedicated LNG-only and dual-fuel ocean-going vessels are being designed or built.

Biodiesel

15 Biodiesel is also attracting more attention, due to a number of technology developments and regulatory biofuel requirements, especially in the United States and Europe. There is increased interest in biodiesel for the marine sector, especially due to developments toward "drop-in" biofuels, a wide range of biofuels that meet the specifications of conventional fossil fuels and can be readily handled in the existing infrastructure.

16 The current focus of drop-in biofuels is to replace some fraction of diesel fuel, which is used in vehicles and vessels that cannot be readily electrified. The main advantage of biodiesel for such marine applications is its ability to replace conventional marine fuels without requiring substantial modifications to the engine, fuel line, or tank components. In addition, biodiesel fuels can be derived from a variety of biomass feedstocks, including crop residues, woody biomass, dedicated energy crops, and algae.

17 Benefits of using biodiesel include the potential for almost complete elimination of marine SO_x emission, as well as potential cost savings due to biodiesel's improved lubrication characteristics. Biofuels from many sources can potentially reduce life-cycle GHG emissions, depending on the particular biomass pathways from which the biodiesel is derived.

18 As of 2012, biofuels in the marine area are in early testing phases. Tests have been done to analyse the compatibility between biodiesel and marine diesel engines, as well as the emission reduction potential. Results in 2012 suggest that biodiesel essentially eliminates SO_x emission. The results from a larger-scale testing program will be made public in 2013 as Maersk and the United States Navy conclude their biofuel testing.

19 The main barriers for biodiesel are cost and availability. The marine sector has to compete with the on-road sector for any potential fuel feedstock (as well as with stationary sources for any biomass fuel supply). Generally the on-road sector is paying, and will continue to pay, higher fuel costs and could thus tolerate higher costs for drop-in biodiesel supply than the marine sector. Gradual long-term development in advanced cellulosic or algae-based fuels could offer the potential for far lower fuel carbon intensity. However, large-scale marine use of biofuels is likely to be contingent upon the shipping sector accepting fuel prices approaching those in the on-road transportation sector. In addition, biofuels may in some cases lead to marginal increases in NO_x emissions and increased corrosion due to its acidity. Finally, biofuels come from many diverse feedstocks and production pathways, and associated issues related to their broader sustainability and life-cycle emissions may need to be addressed through other policies.

Conclusions

20 Based on the review, the ICCT and IMarEST made the following observations:

.1 The technical equivalent measures that are identified here have made substantial progress toward technical maturity and economic feasibility. The technical refinement of scrubbers, the building of LNG bunkering facilities, and the further development of drop-in biodiesel will further motivate the development of guidelines for their potential designation as equivalent measures. There is also an urgent need for the industry to have greater certainty about these potentially equivalent SO_x emission-reduction technologies, as 2015 ECA requirements are fast approaching.

.2 The data on marine technologies for SO_x reduction are fragmented, despite their great importance. To date, there has not been a concerted approach to collecting, compiling, and disseminating the data, in a similar manner to energy efficiency technologies and black carbon mitigation technologies. A thoroughly investigated, peer-reviewed report on equivalent technology that is directed by the IMO could serve to greatly deepen the joint industry, policymaker, and public understanding of the opportunities, uncertainties, costs, and benefits for these technologies.

.3 While compiling the database and interviewing policymakers and industry practitioners, it was found that a number of emission measurement tests, supported by government, technology providers, and shipping companies, are being planned to quantify the associated SO_x emission reduction from LNG, scrubber, and biodiesel technologies. Broad communication regarding the development of testing protocols, the public dissemination of data, and compilation of the data in high-level overview materials will help to make better business, policy, and environmental protection decisions in the future.

.4 The database created by the ICCT in collaboration with the IMarEST could be a starting point for such an overview. The ICCT will continue to update the database and invite representatives from industry, governments, and other stakeholder organizations to provide feedback and additional information. The ICCT will also make the database free for download in order to facilitate data exchange among all interested parties.

Action requested of the Sub-Committee

21 The Sub-Committee is invited to note this document and take action as appropriate.

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