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AIR POLLUTION AND ENERGY EFFICIENCY

EEDI Reduction beyond phase 2 – Consideration of technical issues affecting future evolution of the EEDI regulation and decarbonising shipping

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SUMMARY

Executive summary:	The co-sponsors call the attention of the Committee to a range of technical issues and challenges which will need to be considered in order to properly evaluate further evolution of the EEDI regulation and facilitate informed decision making. The co-sponsors also provide proposals to improve the processes of the Organization when considering EEDI reduction rates.
Strategic direction, if applicable:	3
Output:	3.5
Action to be taken:	Paragraph 48
Related documents:	MEPC 73/19, MEPC 73/WP.7, MEPC 73/5/1, MEPC 73/5/9, MEPC.308(73), MEPC.304(72) and MEPC.203(62), and MEPC.1/Circ.850/Rev.2

Introduction

1 Resolution MEPC.203(62) which amended MARPOL Annex VI to incorporate the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) was adopted by IMO in 2011, introducing legally binding energy efficiency requirements. This was a milestone event, introducing the world's first global mandatory energy efficiency requirements, applicable to an entire industry across all countries. The measures entered into force on 1 January 2013

2 As part of the IMO roadmap for developing a comprehensive strategy on reduction of GHG emissions from ships, the Initial IMO Strategy on reduction of GHG emissions from ships (MEPC.304(72)) was adopted (the Initial Strategy). The shipping industry welcomed the adoption of the Initial Strategy and considers it to be a major step forward for the international shipping sector, setting out a pathway for the phase-out of GHG emissions.

3 The Initial Strategy includes a number of candidate short-term measures, including further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, taking into account the outcome of the review of EEDI regulations (paragraph 4.7.1, MEPC.304(72).

4 The Committee is currently reviewing the EEDI regulations. MEPC 73 considered the matter of EEDI beyond phase 2 and will give the matter further consideration at MEPC 74 (MEPC 73/19, paragraphs 5.55 to 5.59 and 5.80 to 5.83).

5 The co-sponsors consider that the EEDI regulation has made an important contribution to lowering GHG emissions from ships, and that it can make an important contribution to further reductions as part of the Initial Strategy. However, it is also considered to be essential that the Committee properly considers a range of technical matters and is cognisant of the wider technical challenges which will face ship designers, ship builders and shipowners as the industry progressively lowers GHG emissions from ships to meet the objectives of the Initial Strategy. The important and far reaching consequences of decisions which will be made by the Organization in the years ahead must be technically informed and avoid wrong turns.

6 This document highlights a number of questions and challenges, and makes proposals for the consideration of the Committee.

Overview of current status and challenges

7 Further strengthening of the EEDI regulation along with measures to meet the levels of ambition of the Initial Strategy mean that shipping is facing a period of revolutionary change. Developing and commercialising the necessary technologies, along with the infrastructure needed to support them, will be a huge undertaking. This will almost certainly necessitate adopting both transitional technologies and fuels (for example, changing to alternative lower carbon fuels such as LNG) and long-term solutions once zero or very low carbon technologies are commercialised.

8 There is a range of challenges associated with developing and commercialising new technologies for ships, some of which may not be fully appreciated by all. When considering the EEDI regulation it must be understood that this is a ship <u>design</u> efficiency measure, not a ship operational efficiency measure. This critical distinction must be understood, i.e. the EEDI value is established using the EEDI calculation for a clearly defined condition and verified on trials. It is not concerned with, for example, speed optimisation in normal operation. Improving operational efficiency of ships is addressed in the SEEMP, not in the EEDI regulation.

9 The safety of seafarers, passengers and other affected persons should be paramount when considering new technologies. Crews and support staff need to be able to operate and maintain systems. Safety and consideration of human factors must not be marginalised while the Organization considers further strengthening of the EEDI regulation and implementing the Initial Strategy.

10 Technologies which perform well in laboratories and land-based applications can be found wanting when installed on board ships. Motion, vibration, humidity, salt, space constraints, remoteness from external specialist technical support and other factors can conspire to defeat solutions which work well in other applications and it is easy to underestimate the challenge of marinising technology or assume that existing land-based designs can be applied to ships.

11 A technology may work well within defined ambient conditions (for example, seawater temperature and composition) but not outside these conditions. If a ship operates globally then this may mean that key systems cannot be used in some parts of the world.

12 There is a wide range of promising technologies which have good potential to reduce EEDI values and also to meet the levels of ambition of the Initial Strategy. However, many of these promising technologies have either not been commercialised, or not developed for maritime application. There is a significant difference between promising laboratory results or even a successful trials installation and commercialisation of a technology. A further problem is that impressive claims may be made for technologies based on analysing performance under ideal conditions which are not representative of how it will be used in service, or based on inappropriate comparisons with alternatives. For example, a comparison may be made between a ship which has just had its hull cleaned while fitting a new design propeller and a sister ship which has been in the water for several years with an older propeller design, how much of any measured differences is the result of the new propeller design and how much the cleaner hull?

13 Proscriptive rules based on known and existing technology are not ideal for facilitating adoption of new technologies and have sometimes acted to retard innovation. The move towards goal-based rules has eased this process, however a goal-based regulation or rule will only be effective if those applying it have sufficient knowledge and a detailed understanding of the technology in question and its associated risks. As the industry enters a period of great change it is essential that development of safety and risk management regulations (such as amendments to the SOLAS Convention and other IMO instruments addressing safety) keep pace with technological evolution and that safety requirements are not relaxed in order to facilitate emissions reduction.

14 The EEDI regulation may not be well adapted to some new technologies, so that ships will not receive the appropriate benefit when calculating the EEDI value. The co-sponsors concur with document MEPC 73/5/9 (RINA) on this matter.

EEDI reduction - improving efficiency and reducing propulsion power

15 In practice the easiest way to reduce the EEDI value of ships is to reduce engine power output, however, there is a risk that a ship may lack the power required to operate safely in adverse weather conditions if engine power is reduced excessively. This concern led the Organization to develop interim guidelines for minimum power (MEPC.1/Circ.850/Rev.2).

16 Reducing power whilst maintaining sufficient power to manoeuvre in adverse conditions is a conflicting concept and the use of a shaft power limitation has been proposed. A proposal to develop requirements for shaft power limitation was considered at MEPC 73 (MEPC 73/5/1). The Committee did not support paragraph 13 of the document which had proposed removing mandatory minimum power requirements but otherwise invited interested delegations to continue developing the idea. The co-sponsors could support this work, and see the concept as a potentially useful transitionary measure, however this work should be undertaken after the minimum power requirements have been agreed and finalized. In addition, it is expected that as the EEDI is strengthened the difference between the necessary EEDI power rating and the reserve power rating will steadily grow and could reach a point where use of a shaft power limit becomes impractical.

17 A wide range of energy saving techniques is already used to make ships more efficient, such as hydrodynamically optimised hull design, use of variable frequency drives to lower electrical power demand, advanced heat recovery, aerodynamic optimisation of top sides, low friction hull coatings, swirl vanes, rudder bulbs, power take-in/take-off systems, pre-swirl ducts, battery hybrid power systems, hull lubrication and wind assistance, using devices such as Flettner rotors.

18 Some options available to naval architects to ease EEDI compliance cannot be considered wise. For example, reducing the size of bulk carriers and tankers would ease EEDI phase 3 compliance because of the profile of the EEDI baseline for these ship types, but it would also result in less efficient ships. A greater number of such ships would be needed to maintain transport supply. The co-sponsors cannot recommend support for making less efficient ships simply because to do so eases compliance with regulations intended to improve the efficiency of ships.

19 Notwithstanding the distinction between design and operational efficiency (see paragraph 8) the effectiveness of efficiency improvement technologies and actual delivered efficiency improvement is dependent on how the ship is operated. There is some evidence that in-service efficiency may in some cases be compromised in order to achieve the necessary EEDI reduction at the conditions defined for the EEDI calculation. This should be avoided.

20 Although wind assistance has great potential to reduce GHG emissions further, it is considered that most of the available technologies to improve efficiency without switching to lower carbon (or carbon free) fuels and energy carriers will have been fully utilized before EEDI phase 3 takes effect. Therefore, further EEDI reductions will require changing to alternative fuels, energy carriers and propulsion technologies. This is particularly the case for large bulk carriers and tankers, which have reached a point of diminishing returns if looking at efficiency improvement options beyond fuel switching.

EEDI reduction - switching to lower carbon fuels

21 Switching to alternative fuels does not improve energy efficiency, but the lower the CO_2 carbon factor (C_f) of fuels such as natural gas in the EEDI calculation means that switching to such fuels will improve a ship's EEDI value. The calculated energy efficiency of ships may actually deteriorate when switching to alternative fuels due to the loss of deadweight from additional equipment, such as independent fuel tanks, or the use of low energy density fuel.

22 Some alternative fuels are still fossil hydrocarbon fuels, or are derived from fossil hydrocarbon feedstock, for example natural gas (stored on board as Liquefied Natural Gas, (LNG)), Liquefied Petroleum Gas (LPG), ethane and methanol (although methanol can be produced from renewable feed stock, almost all commercially available methanol is produced using natural gas). The lower C_f of, for example, LNG results in an estimated EEDI reduction of around 16 - 17% (it is not as simple as looking at the lower C_f since the electrical load will be higher to operate cryogenic plant and other necessary design changes to the ship), however fugitive emissions of natural gas (such as methane slip from gas engines) would significantly impact the GHG intensity benefit since methane is a much more potent GHG than CO_2.[1] Further study is required to quantify and evaluate fugitive emissions (including methane slip) from LNG fuelled ships.

23 Biofuels including both biofuel replacements for fuel oil and biogas methane have been advocated as short-term to mid-term solutions to lower GHG emissions from ships. For the purposes of the EEDI calculation there is no assigned C_f for biofuels, therefore no benefit for a ship's EEDI value. Some analysis has questioned the GHG benefits of biofuels and there are further concerns with respect to impacts on biodiversity as a result of land use changes. These issues are particularly acute for the more traditional biofuels (such as fatty acid methyl ester/FAME biodiesel) and there is increasing societal awareness of land use problems. The production of traditional biofuels increases N_2O production which is a much more potent greenhouse gas than CO_2. There is extensive research to develop next generation biofuels using algae and other sources intended to avoid these issues, however it is unclear how successful or economically viable these alternatives will be.

[1] Intergovernmental Panel on Climate Change (IPCC), Climate Change 2013: Physical Science Basis, Anthropogenic and Natural Radiative Forcing, page 714

24 The fuels considered in this section could all reduce GHG emissions, however, some of them require major investment in terms of supply and distribution infrastructure, most are associated with a significantly higher risk profile (for example, lower flashpoint of natural gas, toxicity of methanol, low flashpoint and heavier than air weight for LPG) and in some cases it is not practicable to convert existing ships (eg. LNG). If biofuel is to be used as a facilitator to reduce EEDI values then suitable C_f values are required. In the longer term, carbon-free or at least very low carbon fuels or energy carriers will be needed to achieve the 2050 level of ambition provided in the Initial Strategy.

EEDI reduction - carbon free alternative fuels

25 If shipping is to be decarbonised it will need to either adopt zero carbon fuels or alternative energy carriers such as batteries. Since the C_f of a carbon-free fuel would presumably be zero and this would result in the EEDI value of a ship being 0. Options include hydrogen, and hydrogen carriers such as ammonia.

26 Hydrogen can be utilized as a fuel for fuel cells or used to fuel internal combustion engines, with the products of combustion being carbon free and potentially limited to just water and heat (however, if used to fuel internal combustion engines then emissions may include NO_x and hydrogen peroxide). The environmental credentials of hydrogen are determined by the means of production, with most commercially available hydrogen being produced using steam reforming of natural gas in an energy intensive process however it can be produced using water as a feedstock by electrolysis. There is significant research underway to develop clean, energy efficient process for producing hydrogen from water using thermochemical processes. The shift to renewable energy to power electricity distribution networks on land (such as wind and solar) could enable the supply of environmentally clean hydrogen. A switch to hydrogen fuel by shipping would require a huge investment in a production, transport and storage infrastructure.

27 Hydrogen has a very wide flammable range (4 - 75% in air at atmospheric pressure) and a very low minimum ignition energy. Hydrogen embrittlement of metals may lead to leakage of hydrogen. If carrying liquid hydrogen then it would need to be cooled below -252°C at atmospheric pressure, this is significantly below the temperature required to liquefy LNG, compressed gaseous hydrogen would be impractical except for smaller ships engaged in very short voyages, such as riverine craft. This means that it would require robust controls to manage risks and ensure the safety of hydrogen fuelled ships.

28 An alternative to carrying liquefied or compressed hydrogen is to use a hydrogen carrier such as ammonia. Ammonia could be used as a fuel directly or used with hydrogen fuelled systems after dehydrogenation, avoiding the cryogenic systems necessary for the carriage of liquid hydrogen. Liquefaction of anhydrous ammonia is possible at a pressure of 81 MPa when temperature is lowered to -33° (similar to propane gas). Ammonia can also be stored as an aqueous solution which is much safer than anhydrous ammonia. Although most ammonia is produced using natural gas as a feed stock, it is possible to produce ammonia using only air and water. The increasing availability of carbon-free renewable forms of electricity generation from wind and solar energy sources mean that these alternative methods of production are increasingly attractive.

29 There are, however, significant safety risks associated with ammonia: it is toxic and hygroscopic. Although in dilute solution the safety risks are much less, exposure to gaseous anhydrous ammonia can cause caustic burns, lung damage and death. Anhydrous ammonia gas is heavier than air, meaning there is a risk of clouds forming under leak points. Some types of fuel cell stack are incompatible with ammonia, so that even very small quantities of ammonia remaining after reforming into hydrogen could seriously affect fuel cell performance.

30 Hydrogen could be reformed on board from almost any feed stock containing hydrogen to ease fuel storage and handling and minimize the risks associated with hydrogen gas, however these reforming processes can be hazardous themselves and some of the feed stocks proposed are more hazardous than conventional oil fuels.

Fuel life cycle analysis

31 The life cycle analysis of the impacts of fuels must be understood. This is to try and avoid industry and society committing to fuels subsequently found to be non-acceptable as a result of wider environmental impacts. This largely depends on how system boundaries are defined and which assumptions are used for the analysis. As such, the co-sponsors consider that it is essential for IMO to agree guidelines for fuel life cycle GHG analysis.

Carbon capture

32 Carbon capture and storage technologies have been under development for a number of years. This may take the form of removing CO_2 from the exhaust gas, or alternatively there have been proposals to develop direct air carbon capture.

33 The co-sponsors consider that carbon capture from exhaust gas and storage on board is unlikely to become a viable proposition, and should this change it is expected to be many years away. Direct air carbon capture is considered to be more viable, it may be possible to develop onshore or offshore direct air carbon capture facilities to remove an equivalent quantity of CO_2 as is emitted from defined ships.

34 A third option would be to separate carbon before combustion, retaining it on board until it could be discharged and then recombined with, for example hydrogen, to produce methanol. This would facilitate methanol becoming in effect a carbon-free fuel at point of use.

EEDI reduction - alternative energy carriers and energy conversion

35 There are a number of technologies to reduce GHG emissions from ships and to improve efficiency, however as noted in paragraph 14 the existing EEDI regulatory framework is not well adapted to some of these technologies. The co-sponsors consider that it is essential that the EEDI regulation should properly recognize all GHG emission reducing technologies. The treatment of innovative technologies in the *2018 Guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships* (MEPC.308(73)) is quite limited.

36 Pure battery power is currently suitable for small ships engaged on short voyages. There are already larger RoPax conversions and offshore support vessels using hybrid power and propulsion technology similar to that used in the automotive sector to optimise efficiency and reduce fuel use. In the longer term it may be possible to utilize batteries as the primary source of power for larger, ocean-going vessels. Large batteries are expensive, the high energy density of modern batteries imposes additional risk management requirements and existing battery chemistries tend to require rare and/or heavy metals. The availability of sufficient materials to manufacture batteries of the necessary power, affordably, could be a limiting factor to the viability (or otherwise) of battery-powered ships. It would also be necessary to develop suitable electrical connections (and the supply of electricity) capable of recharging very large batteries quickly without degrading their performance to avoid congestion in ports arising from extended port stays. Pure battery power will require adjustments to how ships are operated and careful route management as well as development of a recharging infrastructure.

37 Wind power is freely available at sea and sails are an effective means of propelling ships, as evidenced by the many centuries of sail power. However, efficiently harnessing this "free" energy can be expensive. Modern wind power technologies include aerofoil wing sails kites and rotors as well as more conventional sails. Most of these technologies have already been used to assist in powering commercial ships with positive results. Wind power is attractive for certain trade routes, however, it is intermittent and directional. This can be mitigated by using wind power in conjunction with energy storage or more conventional propulsion systems. The co-sponsors consider wind energy will most likely augment, not replace, other forms of power such as engines, batteries or fuel cells.

38 Solar energy can be utilized using photovoltaic cells to produce electricity, or by solar thermal systems to generate heat energy. The main limiting factor is the available surface area of a ship, meaning that solar energy would most probably augment and not replace other forms of energy conversion. They could however improve efficiency and reduce emissions, the intermittency of solar energy can be mitigated by using it in conjunction with energy storage and more conventional forms of energy conversion.

39 Nuclear energy is technologically mature, reliable and capable of meeting any conceivable power demands which can be anticipated for maritime applications. However, there is significant political and societal resistance to nuclear energy and the co-sponsors consider it highly unlikely that it will be adopted for commercial shipping.

Discussion

40 The co-sponsors consider that EEDI reduction beyond phase 3 for all ships, and beyond phase 2 for some challenging ship types, such as large tankers and bulk carriers, will require the adoption of new fuels, energy carriers and technologies. This document has considered a range of options, the options considered are not exhaustive and new ideas are being proposed on an ongoing basis.

41 Many of these technologies change the risk profile of on board systems by introducing fuels and materials which are flammable and toxic, and potentially hazardous processes such as fuel reforming. Some of the technologies would require significant changes in operating practices, for example routing of pure battery-powered ships will be determined by battery capacity.

42 These changes will profoundly alter the industry as new technologies are increasingly adopted. An evidence-based and technically sound process to consider the status, effectiveness and time needed to commercialise and introduce such technologies when considering further EEDI reductions and implementation dates will be essential.

43 This process needs to be evidence based and determined by scientific and technical analysis and it is essential that ship builders, equipment designers and energy experts are fully engaged along with governments and ship owners.

44 The regulatory framework must be fit for purpose both in terms of managing risk, and properly reflecting the efficiency improving and/or GHG reduction benefits of technologies in the EEDI calculation.

Proposals

45 The magnitude of technological change which will be necessary to achieve further EEDI reductions means that it is essential to make rational and evidence-based decisions. Further, there must be transparent processes for making such decisions. This will promote good regulation making and ensure that the EEDI regulation continues to act as an effective mechanism to promote efficiency improvement. The co-sponsors consider that the existing EEDI database will be of limited utility for informing discussions on further EEDI reduction rates and implementation dates as ships increasingly adopt new and innovative technologies.

46 The co-sponsors propose that the Organization should:

.1 finalize minimum power requirements for tankers and bulk carriers before initiating the process of further reducing EEDI values of such ships;

.2 review the *2018 Guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships* to ensure that the EEDI calculation reflects the benefits of new and innovative technologies;

.3 consider developing guidelines for quantifying and demonstrating the effectiveness of new technologies to ensure transparency, to avoid making decisions based on erroneous claims for GHG reduction and efficiency improvements offered by particular technologies;

.4 develop guidelines for fuel life cycle analysis, to be reflected in fuel C_f values for the EEDI calculation;

.5 develop a process for how further EEDI reduction rates and implementation dates will be developed, to ensure that decisions are based on sound analysis and data and taken in a transparent manner. Currently it appears that these decisions are based on proposed reduction rates and implementation dates submitted to correspondence groups and at sessions of the Committee with very little transparency or rationale supporting these proposals. The nature of change facing the industry means that such an extemporised process will no longer be supportable; and

.6 in considering further EEDI reduction rates and implementation dates, consider the readiness of technology, supply of fuels and ensure that safety matters (including consideration of the readiness of the Organizations safety regulatory framework to address risks associated with new technologies).

47 The co-sponsors consider that the measures proposed in paragraph 46 would facilitate adoption of new technologies intended to make shipping more efficient and reduce GHG emissions and ensure that the EEDI remains fit for purpose as ships and marine technologies evolve to meet the challenges of decarbonising.

Action requested of the Committee

48 The Committee is invited to consider the comments and proposals contained in this submission and to take action as appropriate.

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