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PREVENTION OF AIR POLLUTION FROM SHIPS

Consideration of the Energy Efficiency Design Index for New Ships

Refinements to the "draft guidelines on the method of calculation of the energy efficiency design index for new ships" for non-conventional passenger ships

Submitted by Cruise Lines International Association (CLIA)

SUMMARY

Executive summary:	This document describes the work done to date by CLIA to address issues with the proposed EEDI formulation contained within annex 2 to MEPC 59/4/2 that are particular to new non-conventional passenger ships. These refinements include familiarization with propulsion power correction for redundancy, correction for gear boxes, an improved *SFC*, improved formulation for the efficient use of energy and a diagram of the marine plant.
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.2 and 7.3.1.3
Action to be taken:	Paragraph 22
Related documents:	GHG-WG 2/2/19, GHG-WG 2/WP.1, GHG–WG 2/2/21; MEPC 59/4/12 and MEPC 59/4/2

Introduction

1 The second Intersessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships (GHG-WG 2) continued the development of the draft Interim Guidelines on the method of calculation of the Energy Efficiency Design Index (EEDI) for new ships. Document GHG-WG 2/2/19 (ICS, CLIA, INTERFERRY and the Marshall Islands) highlighted problems with applying the then current formulation of the EEDI to non-conventional passenger ships including all electric and hybrid propulsion ships. An improved EEDI formulation for these ship types was introduced by CLIA (GHG-WG 2/2/21) and addressed the complexity of the marine

plant proposing a revised wording, diagram and a rigorous formal approach suitable for the mentioned ships.

2 During GHG-WG 2, the specific application of the EEDI to these ship types was not discussed. Consequently the only aspects of documents GHG-WG 2/2/19 and GHG-WG 2/2/21 that were discussed were those that were also applicable for conventional passenger ships.

3 As stated at GHG-WG 2, CLIA has worked further on an EEDI formula for all electric and hybrid propulsion ships and has identified the possibility to extend the current formula, which is clearly only aimed to conventional ship-types.

4 CLIA remains of the view that this new proposal is less valuable than the one contained in document GHG-WG 2/2/21, however, it could lead to an easier familiarization with all electric and hybrid propulsion passenger ships, in particular of those who have little experience of such complex types of ships.

5 CLIA proposes that a preliminary investigation for the mentioned ships peculiarities should be held during MEPC 59, in preparation to finalize discussions at MEPC 60.

6 As a consequence, there are a number of refinements to the current formula and these are shown below. Only the primary issues of all electric and hybrid propulsion ships are introduced here.

Objective

7 This document proposes detailed refinements to the guidance contained in MEPC 59/4/2, annex 2 "Draft guidelines on the method of calculation of the energy efficiency design index for new ships".

8 Proposed refinement to the current formulation are shown in paragraph 12.1 below where the relevant paragraph of document MEPC 59/4/2, annex 2 is quoted. The addition of text is shown by underlining and the deletion of text is shown by ~~strikethrough.~~

9 CLIA, in coordination with other industry experts, continues to work on proposals to address issues related to electrically powered cruise ships, and hopes to be able to share the work with the Committee at this session.

Propulsion power correction for redundancy

10 The current formula does not address the redundancy of the shaft motors (PTI) and main engines that is common for all electric and hybrid propulsion ships, leading to a potential error in the EEDI calculation. As a consequence, redundancy for shaft motors and main engines would be penalized for future ships. Moreover, the marine plant designer would have reduced opportunities to develop innovative propulsion configurations.

11 The sum of the shaft motors and main engines rated power is not always fully deliverable to the propellers because it can be limited from various systems (for example, by the propulsion limitation control system, gear boxes maximum torque/power, etc.). This issue arises in ships whose marine plant is complex where, for example, shaft motors drive the propeller shaft with other motors/gas turbine/main engines via gear boxes.

12 As a consequence, an amendment to the formula is necessary to introduce this concept.

12.1 Proposed amendments to paragraph 2.5.3:

> In case the combination of each main engine's power and each shaft motor's rated power is limited by a permanent system that is documented and certified, the main engine's power and shaft motor's powers are to be reduced by this limit prior to the calculation of $P_{ME(i)}$ and $P_{PTI(i)}$.

Propulsion power correction for gear boxes

13 To date the design of marine plant with gearboxes has not been considered within the EEDI formula. Gear boxes can lead to losses ranging from 2 to 3% of their input power. As a consequence, the error that occurs by not considering them is fairly significant, potentially penalizing the all electric propulsion against the conventional propulsion plants.

13.1 For a typical example, ships with (????) the EEDI error could be ~ 1.5%.

13.2 Therefore, an amendment to the formula is necessary to introduce this concept.

13.2.1 Proposed amendments to paragraph 2.5.3:

> Wherever shaft motors and/or main engines drive the propeller via gearboxes, their power has to be divided by the efficiency of the gearboxes, as per manufacturer's documents, prior to the calculation of $P_{PTI(i)}$ and $P_{ME(i)}$.

SFC for auxiliaries engines correct calculation for hybrid and all electric propulsion ship

14 For all electric and hybrid propulsion ships, the auxiliary engines should be defined as "main source of electric power" according to the SOLAS (see CLIA document GHG-WG 2/2/21). The auxiliary engines provide power for auxiliaries and also for propulsion. They are separated from the propulsion motors and they are normally organized as multiple-generators system that have a number of possible different engine combinations which can lead to different *SFC*. The current formula does not properly address the complexity of the auxiliary generators configuration where the auxiliary power can be provided by a number of prime movers coupled with alternators (see CLIA document GHG-WG 2/2/21). Typically these might be diesel engines coupled with alternators, gas turbines coupled with alternators, or steam turbines coupled with alternators. Electric generators can also deliver auxiliary electric power P_{AE} and/or propulsion power $P_{PTI(i)}$ without the provision of alternators (for instance, fuel cells generators, etc.). To date, normally for generators with medium-speed diesel engines as prime movers, the individual most efficient loading is at 85% of the rated maximum power (85% leads to a lower *SFC* for diesel engines) and, by design, they are seldom loaded below the 50%-60%. For gas turbines the individual most efficient loading is at 100% of the maximum rated (100% leads to a lower *SFC* for gas turbine) power but they can also be loaded lower than 50%.

15 As a consequence, the generators' management control system is typically designed to start/stop and load the generators to supply the auxiliaries load P_{AE} and/or propulsion power $P_{PTI(i)}$ but also to match the highest possible efficiency letting them run at their individual most efficient load point. The optimal configuration of the number of running generators and their load percentages changes upon the power P_{AE} and/or propulsion power $P_{PTI(i)}$. Once P_{AE} and/or propulsion power $P_{PTI(i)}$ is calculated with the criteria illustrated within the formula, the most

efficient auxiliary generators' configuration is **only one** and can be easily identified, included in a document and verified by the class and flag authorities. This configuration is to be used for the SFC_{AE} definition. Moreover, the auxiliary generators' number, type and rated power vary upon the level of redundancy that new ships have to comply with. For example, gas turbine generators can be used as compact-spare units for navigation where the use of a diesel engine is not allowed for the purpose of air pollution regulation. However, they do not contribute in the normal seagoing conditions at *Vref* but they would be included in an EEDI with the current formulation. As the gas turbines generators have a much higher individual *SFC* if compared with the diesel engine generators *SFC*, it will result in an incorrect EEDI calculation (it would be like considering the CO_2 produced by the gas turbine even if they are off by design). This makes it clear that the calculation of SFC_{AE} weighed as average among the $SFC_{AE(i)}$ needs to be complemented with the "optimal working point concept" for passenger non-conventional ships. Calculations have been carried out for some classes of new and existing ships, showing that the following error in the EEDI could result.

15.1 Error led by calculating EEDI with and without the "optimal point concept" ~ 5%.

15.2 As a consequence an amendment to the formula is necessary to introduce this concept.

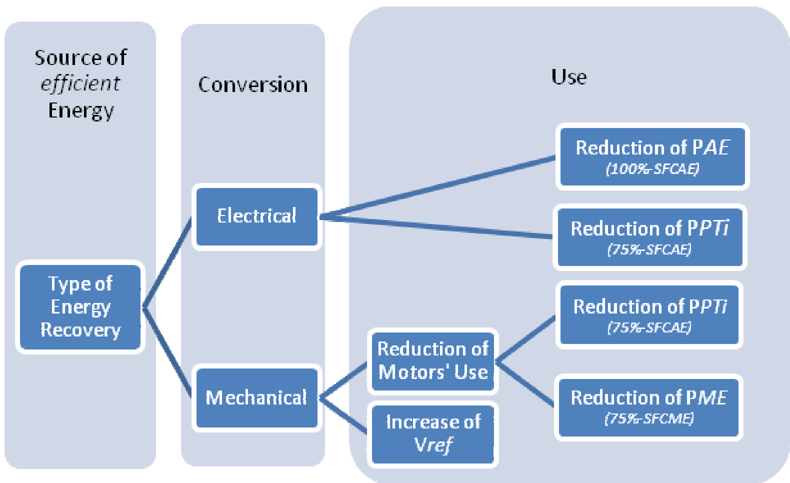
15.2.1 Proposed amendments to paragraph 2.7:

For non-conventional passenger ships SFC_{AE} is to be calculated at the best achievable combination of the respective engines *i*. Such a configuration must be permanent and true available thorough the control systems and must be shown and demonstrated in a document.

Efficient use of energy

16 The current formulation does not properly address the efficient use of energy for a number of reasons; some of them are detailed via examples hereafter.

17 The following diagram demonstrates the efficient use of energy concept. It shows that any type of energy recovery can be used in several different ways that apparently has not been considered by the current EEDI formula.



17.1 With reference to the above diagram, the following "Type of Efficient use of Energy" have been identified: 1) Main Engine Waste heat recovery, 2) Auxiliary engines Waste heat recovery, 3) Wind Power, 4) Solar Power, 5) CO_2 capturing, 6) air lubricating and 7) new future ship and propulsion types.

17.2 From the above diagram, it is easier to understand that power resulting from a "type of efficient use of energy" can lead to a different EEDI upon its conversion and use. For example, the waste heat recovery from the auxiliary engines can be converted into electrical power via a steam turbine generator. Such electrical power can be utilized to supply a part of the auxiliary power (P_{AE}). Alternatively, it could be utilized to supply a quota of the shaft motors' power ($P_{PTI(i)}$). The current formula infers that the electrical power from energy recovery (*PAeff*) can reduce the auxiliary power (P_{AE}) only and not the power $P_{PTI(i)}$. This is not always possible as shown in the document GHG-WG 2/2/17; potentially the power for energy recovery could be greater than the total power P_{AE} and consequently the excess power must contribute to the power $P_{PTI(i)}$. As the current formula state that P_{AE}*'s* CO_2 production has to be considered at 100%, while the $P_{PTI(i)}$*'s* CO_2 production has to be considered at 75%, this example demonstrates that the EEDI can substantially vary upon the use of the energy recovery and the calculation method of the EEDI.

18 In the current formula the use of innovative mechanical energy efficient technology (*Peff*) can be used only as reduction of the main engine power $P_{ME(i)}$ (*Peff* is actually multiplied by the SFC_{ME}). This restriction artificially limits the best use of the mechanical energy efficiency. In a ship where the propulsion power is given by the sum of $P_{PTI(i)}$ and $P_{ME(i)}$ and where $P_{PTI(i)}$ have a bigger CO_2 production per kW (as auxiliary engines have a higher SFC than Main engines) a propulsion control system should be designed to reduce the $P_{PTI(i)}$ first and the $P_{ME(i)}$ in second place. However, the actual formula does not allow calculating the EEDI by considering the reduction to $P_{PTI(i)}$ for mechanical energy efficient systems.

19 The innovative mechanical energy efficient technology could also be used to increase the ship's speed and not only to reduce the propulsion's power. The actual EEDI formula does not allow considering this option. For example, wind traction systems could be used to reduce the propulsion's power at *Vref* as constant or increase *Vref*, up to the operator's commercial strategies or upon the best EEDI calculation. The same problem could arise in case of air lubrication systems.

20 A better definition of the "Efficient use of Energy" within the EEDI formula is proposed to address the major concerned identified above.

20.1 Proposed amendments to paragraphs 2.5.4 and 2.5.5:

.5.4 $P_{effM(i)}$ is [75 % of] the main engines' and/or shaft motors' power reduction* due to innovative mechanical energy efficient technology

*Upon the verifiable use of the innovative mechanical power

Mechanical recovered waste energy directly coupled to shafts need not be measured.

.5.5 $P_{AEeff(i)}$ is [100% and/or 75 % of] the auxiliary power P_{AE} and/or shaft power $P_{PTI(i)}$ reduction* due to innovative electrical energy efficient technology ~~measured at $P_{ME(i)}$~~

*Upon the verifiable use of the innovative electrical power

20.2 Proposed amendments to paragraph 2

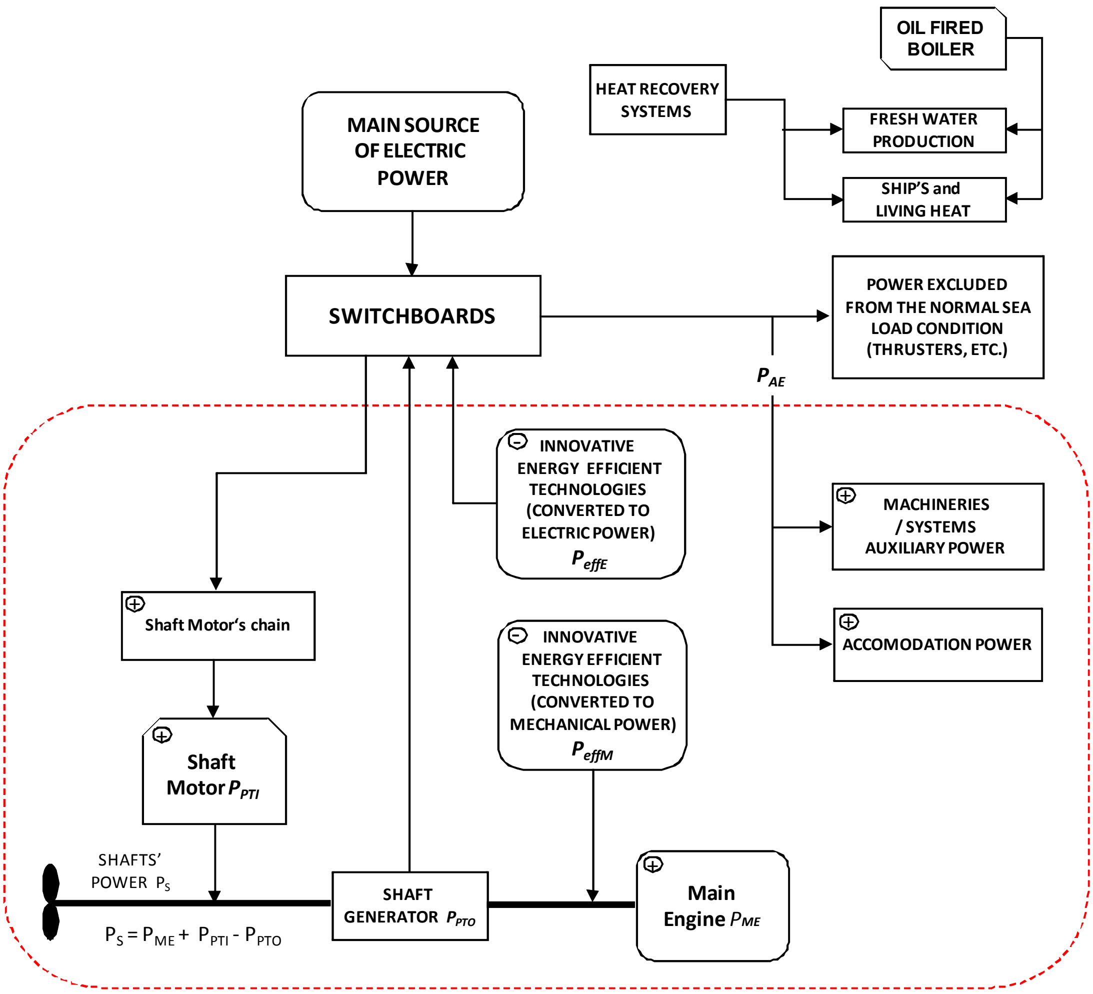
$$\sout{Efficent\ \ use\ \ of\ \ energy = \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} + \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)} \cdot C_{FAE} \cdot SFC_{AE}}$$

$$Efficent\ \ use\ \ of\ \ energy = \frac{\left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{effM(i)} \cdot C_{F\{MEorAE^*\}(i)} \cdot SFC_{\{MEorAE^*\}(i)} + \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{effE(i)} \cdot C_{FAE(i)} \cdot SFC_{AE(i)} \right)}{veff}$$

*CF_{ME} or CF_{AE}, SFC_{ME} or SFC_{AE} to be used upon to the verifiable use of innovative electrical power
$veff$=1 or ship's speed increase coefficient upon the verifiable use of innovative mechanical power. The calculation of $veff$ to be demonstrated in a dedicated document.

Marine plant diagram for non-conventional passenger ships

21 A new diagram is introduced where the circles indicate the CO_2 contribution (+/-) to the EEDI formula.



Action requested of the Committee

22 The Committee is invited to consider the above proposed improvements to the EEDI formula when considering its application to non-conventional powered passenger ships and take action as appropriate.

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