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PREVENTION OF AIR POLLUTION FROM SHIPS

Comments on verification of the proposed Energy Efficiency Design Index (EEDI)

Submitted by the International Association of Classification Societies (IACS)

SUMMARY

Executive summary:	This document provides comments and proposals regarding the verification of input parameters of the Energy Efficiency Design Index (EEDI) as set out in document MEPC 59/4/2
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.3
Action to be taken:	Paragraph 30
Related documents:	MEPC 58/4/9, MEPC 58/4/30, MEPC 58/23; GHG-WG 2/2/1, GHG-WG 2/2/14, GHG-WG 2/2/16 and MEPC 59/4/2

Background

1 MEPC 57 tasked the first intersessional meeting of the Working Group on GHG Emissions from Ships (GHG-WG 1) to develop a design CO_2 index for new ships. At MEPC 58, the Draft Interim Guidelines on the Method of Calculation of the Energy Efficiency Design Index (EEDI) for New Ships were developed. The Committee noted the "two steps" verification process (plan approval and sea trials verification) described in document MEPC 58/4/9 (Denmark) and agreed that a clear description of verification should be provided in the Guidelines if the implementation of the EEDI becomes mandatory. It was also agreed to develop the verification process on the basis of the Danish document and document MEPC 58/4/30 (IACS).

2 During the second intersessional meeting of the Working Group on GHG Emissions from Ships (GHG-WG 2), general support was expressed for the "two steps" verification process and the Group agreed to use document GHG-WG 2/2/16 (Japan) as the basis for further developments. Notwithstanding this, a number of delegations expressed their concerns regarding the proposal for the establishment of a verification procedure as referred to in document GHG-WG 2/2/16. In particular, it was discussed how to address the possible case of a ship that is compliant with the EEDI requirements after the "plan approval" phase but then discovered to be not in compliance with these requirements after "sea trials" verification.

Objective

3 This document aims at exploring verification of the key input parameters used for the calculation of the EEDI by assessing, for the design stage and sea trials, their availability, level of documentation and standardisation as well as possible references to other certificates. In addition, a brief overview is carried out on the existing innovative energy efficient technologies which could be used to reduce the attained CO_2 index. For all the described technologies, suggestions for a possible verification of the relevant parameters in the EEDI formula are proposed.

4 To address the problem highlighted in paragraph 2 above, IACS is of the view that the first phase of the verification process should be limited to an "examination" of input parameters, without a formal "approval". Accordingly, the verification process of the EEDI would be performed in two phases: (1) "data examination" of input parameters, to check compliance with EEDI requirements before proceeding with the construction, and (2) "sea trials verification", to formally verify the ship's EEDI.

5 During GHG-WG 2 it was agreed, for ships where the P_{AE} value calculated by the empirical equation is significantly different from the total power used in the normal seagoing condition (e.g., passenger ships), that P_{AE} should be estimated by the total consumed electric power (excluding propulsion) in the normal seagoing condition (to be given by the electric power table), divided by the conversion factor from diesel engine power to electric power. This table is often verified and approved by Administrations/recognized organizations (ROs). An IACS group has been tasked to analyze how electrical power balance can be approved for use in the EEDI framework. The results of this assessment will be submitted to the Organization as soon as it is available.

Examination of input parameters

Power (*P_{ME}*) and specific fuel consumption (*SFC_{ME}*) of main engines

6 During GHG-WG 2, the definition of P_{MEi} (power of the main engines) was modified by the introduction of the new term P_{PTOi} (output of shaft generators) as follows:

$$P_{MEi} = 0,75\ (MCR_{MEi} - P_{PTOi})$$

According to this change, the verification of P_{MEi} now depends on the verification of P_{PTOi} and MCR_{MEi}.

7 The Maximum Continuous Rating (MCR_{ME}) of main engines is available at the design stage and can be found in the EIAPP Certificate.

8 The output of shaft generators (P_{PTO}) can be calculated by the following formula, according to its definition:

$$P_{PTO(i),} = 0.75 \text{ x output of shaft generator system (kW) / efficiency factor}$$

The output of the shaft generator system can be found in the certificates (factory acceptance tests) of the shaft generator, frequency converter, etc., whilst the efficiency factor (usually a value between 0.8 and 0.9) can be found in the manufacturer's data sheets. As an alternative, for the efficiency factor, a fixed value (e.g., 0.9) can be agreed.

9 The Specific Fuel Consumption (SFC_{ME}) is available at the design stage for a great number of engines. In this case SFC_{ME} can be found in the NO_x Technical File (Specific Fuel Consumption at 75% output of MCR). Where no data is available on specific fuel oil consumption (e.g., an engine which has no parent engine due to new design type or which has a different output), the design value specified by the designer can be used on condition that measurement of fuel oil consumption is to be witnessed by the Administration at the shop test. Similarly, for engines with outputs less than 130 kW which have no EIAPP Certificate and NO_x Technical File, shop test data provided by the manufacturer can be accepted by the Administration or RO. Also in this case, if deemed necessary, the Administration or RO should witness the shop trial in order to confirm the output and fuel oil consumption.

Reference speed (V_{ref})

10 IACS supports the methodology defined by Japan in document GHG-WG 2/2/16 and that shipbuilders should develop power curves to estimate ship speed for full-loaded and sea trial conditions. The power curves used for verification should be accurate and supported with evidence.

11 For the verification of V_{ref}, the following items should be provided by the shipbuilder: speed power curves of sea trial and full load conditions; and outline of the estimation method of power curves (including the calculation of wind forces). In order to verify V_{ref}, the shipyard may be required to provide additional information, possibly including information covered by Intellectual Property Rights.

Power of Shaft Motors (P_{PTI})

12 The P_{PTI} definition agreed by GHG-WG 2 (MEPC 59/4/2) requires dividing the 75% of the rated power consumption of each shaft motor by the weighted average efficiency of the generators. The power output of shaft motors is determined by the manufacturer according to existing IEC and ISO standards and can be found in the relevant technical data sheets.

13 Shaft propulsion electric motors (i.e PTI) are often designed as supplementary propulsion devices and may also be able to act as alternators and generate electricity. When they are used as PTI, the power is supplied by switchboards via power conversion devices (i.e. "shaft propulsion electric motor chain" which typically includes also propulsion transformers, propulsion frequency converters and auxiliaries). The shaft propulsion electric motor chain's efficiency is "ηP_{PTI}" and includes all the losses downstream of the switchboards up to the PTI's shaft mechanical power and also includes the losses of various relevant auxiliaries (for instance the shaft propulsion electric motor excitation, various fans and pumps belonging to the propulsion chain, etc.).

14 In view of the above, IACS is of the opinion that a clear definition for the term "weighted average efficiency of the generator(s)" needs to be developed and the new term ηP_{PTI} (shaft propulsion electric motor chain's efficiency) should be inserted in the denominator of the formula for the determination of P_{PTI}.

Cargo capacity

15 According to document MEPC 59/4/2 (report of GHG-WG 2), deadweight should be used to define cargo capacity for cargo ships, whilst Gross Tonnage, as defined by the International Convention of Tonnage Measurement of Ships 1969, should be used for passenger and ro-ro passenger ships.

16 Deadweight is the difference in tonnes between the displacement of a ship in water of relative density of 1.025 kg/m^3 at the deepest operational draught and the lightweight of the ship, defined as the ship's displacement without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, and passengers and crew and their effects.

17 Deadweight and tank capacities, which are key data at the design stage, are contained in the preliminary stability information. On the contrary, Gross Tonnage is not a part of the key data at the design stage for some ship types. Therefore, a preliminary calculation of the tonnage measurement (containing the volume of each space such as under main deck, superstructure, deck house, etc.) should be prepared by the shipbuilder at the design stage and submitted for verification.

18 For the verification of the deadweight (DWT) and Gross Tonnage (GT), the following items should be provided by the shipbuilder: for DWT, the breakdown list for lightweight and hydrostatic curves or tables; for GT, the preliminary calculation sheet for tonnage measurement and general arrangement.

Sea trial verification of input parameters P_{ME}, SFC, V_{ref}, P_{PTI}, P_{AEeff}, P_{eff} and Capacity

19 The sea trials of the ship after construction (before the delivery to the owner) are ordinarily carried out at a partially-loaded condition (sea trials at maximum design load condition are almost impossible, except for certain ship types).

20 If sea trials are carried out to verify the main parameters of the EEDI formula, and it is not practicable to carry out the sea trials at the maximum design load condition in deep water, it will be necessary to work out a method for obtaining, from the parameters observed during the sea trials, the parameters corresponding to the maximum design load condition.

Power of the main engines (P_{ME}) and specific fuel consumption (SFC)

21 As discussed in paragraph 6 above, the verification of P_{MEi} depends on the verification of P_{PTOi} and MCR_{MEi}. Since MCR_{ME} is defined as the rated installed power for each main engine and is already verified for the issuance of the EIAPP certificate, IACS believes that a further verification of MCR_{ME} during sea trials is not needed.

22 The new parameter P_{PTO}, which is 75% output of each shaft generator, can be recorded from the switch board at maximum sea load required and verified using the coefficient of efficiency of the generator, which is available from the prototype generator's test reports on the test bench. It is acknowledged that shaft generators for some vessels may not be tested at design conditions due to the load not being available (which could be the case for container vessels with large reefer capacity). Concerning the specific fuel consumption (SFC), it was agreed, during GHG-WG 2, that a further verification during sea trials would not be required.

Reference speed (V_{ref})

23 The procedure described in document GHG-WG 2/2/16 (Japan) for the verification of speed can be accepted. The speed at full loaded condition can be verified based on comparison between the observed speed at sea trials and the corresponding speed on the power curve for sea trial conditions, which is developed at the design stage. A procedure to derive V_{ref} on the basis of the two power curves should be developed by the Organization.

24 The requirements for sea trial conditions shall be considered and precisely described in the guidelines to be developed by the Organization. When a correction based on the speed measured during a sea trial is needed, it is to be implemented in accordance with ISO 15016 as stated in document GHG-WG 2/2/16 (Japan), Chapter "Requirements for sea trial" and paragraph 8 of document GHG-WG 2/2/14 (Norway).

P_{PTI}

25 P_{PTI} can be recorded from the electric motor switch board at nominal conditions and corrected using the coefficients of efficiency of the generator(s) and the shaft propulsion electric motors chain's efficiency (ηP_{PTI}) mentioned in paragraph 13 above.

Cargo capacity

26 For gas carriers, chemical tankers and oil tankers, the deadweight can be verified by using the value recorded in the relevant "Cargo Ship Safety Certificate". For other cargo ships the deadweight may be calculated using the approved final stability/load line documentation. The Gross Tonnage of passenger ships can be verified by using the value recorded in the International Tonnage Certificate (1969).

Overview of the existing innovative energy efficient technologies

27 The EEDI formula, as agreed at GHG-WG 2, contains the following new terms: P_{eff} (main engine power reduction due to innovative mechanical energy efficient technologies) and P_{AEeff} (auxiliary power reduction due to innovative electrical energy efficient technologies). IACS believes that clear and exhaustive definitions for these innovative mechanical and electrical technologies should be developed.

28 Based on data collected from manufacturers, a number of innovative energy efficient technologies that could be used to reduce the attained CO_2 index have been identified (see annex). For each considered technology, possible methods on how to express the availability factor (f_{eff}) and verify the relevant input parameters of the EEDI formula are provided.

29 In particular, in analysing a possible way to deal with a reliable availability factor on an unsteady resource such as the wind (use of sails), manufacturers have pointed out that it can only be derived from historical recorded data. The problem of availability-prediction does not only affect sail systems, but also other systems (Flettner rotor, solar panels), which use unsteady natural forces rather than mechanical devices (e.g., optimization of combustion) being available 100% as soon they are installed. Another problem to be considered is, particularly for systems such as fuel cells, the availability of the consumables on the routes as well as the storage capacity.

Action requested of the Committee

30 The Committee is invited to consider the comments and proposals provided in this document and take action as appropriate.

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ANNEX

INNOVATIVE ENERGY EFFICIENT TECHNOLOGIES THAT COULD BE USED TO REDUCE THE ATTAINED CO_2 INDEX

Technology	Availability factor (f_{eff})	Examination of input parameters	Verification Sea Trials
Sails (e.g., Dyna-Rigg)	Percentage depending on shipping routes	Statistical data of certain sailing areas (wind data, defined routes), combined with the forward force (area of sail, hydrodynamic coefficient, hull resistance, propeller, etc.)	Saved fuel consumption within specific sailing areas under defined conditions (wind-force, angle to the wind, etc.)
Kite (e.g., Skysails)	Percentage depending on shipping routes		
Flettner Rotor	Percentage depending on shipping routes		
Optimization of injection	Depending on the installed machinery equipment	EIAPP – Engine Shop Tests (specific consumptions in different load cases)	Fuel consumption and on-line measuring (exhaust)
Optimization of combustion	Depending on the installed machinery equipment	EIAPP – Engine Shop Tests (specific consumptions in different load cases)	Fuel consumption and on-line measuring (exhaust)
Alternative fuels	If engine is capable of using alternative fuels 100% minus availability in ports of call.	EIAPP – Engine Shop Tests (specific consumptions in different load cases)	Fuel consumption and on-line measuring (exhaust)
Contra-rotating propellers	If considered for installation, 100%	Data of tests (e.g., tank testing), or CFD-calculation	Fuel consumption and on-line measuring (increase of speed vs. engine output)
Reduction of hull friction and wave resistance	If considered in construction phase = 100%	Data of trials (e.g., tank testing)	---
Hull maintenance (coating – anti-fouling, etc.)	If installed = 100%	Data of trials (e.g., tank testing) Compliance with coating standards	Flow: fuel consumption over time (e.g., 5 years) and verification of growth on hull
Reduction of displacement (e.g., use of composites)	If considered in construction phase or later = 100%		
Fuel-cells	If installed = 100% minus availability of 'fuels' (e.g., methanol, hydrogen) in ports of call.		
Schneekluth nozzle	If considered for installation, 100%	Data of tests (e.g., tank testing), or CFD-calculation	Fuel consumption and on-line measuring (exhaust)
Cord nozzle	If considered for installation, 100%	Data of tests (e.g., tank testing), or CFD-calculation	Fuel consumption and on-line measuring (exhaust)
Solar energy	Depending on sun-hours	Theoretical ability of generated electrical power substituting needed engine power	Power measuring of solar panels and fuel savings due to less electric energy consumption

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