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PREVENTION OF AIR POLLUTION FROM SHIPS

Calculation of the EEDI for LNG Carrier – Case Study

Submitted by the Republic of Korea

SUMMARY

Executive summary:	This document provides a practical calculation result of the EEDI for LNG carrier adopting the steam turbine propulsion, diesel-electric propulsion and diesel propulsion system, and proposes re-consideration of the baseline for LNG carriers
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.3
Action to be taken:	Paragraph 18
Related documents:	MEPC 58/4/8, MEPC 58/23 and MEPC 59/4/2

Introduction

1 MEPC 58 approved the use of the draft Interim Guidelines on the method of calculation of the Energy Efficiency Design Index for new ships, for calculation/trial purposes with a view to further refinement and improvement (MEPC 58/23, paragraph 4.54.1).

2 MEPC 58 invited delegations and industry observers to disseminate the Interim Guidelines on the EEDI to the maritime community at large, so that adequate experience could be gained on its adequacy as a tool to improve energy efficiency for new ships (MEPC 58/23, paragraph 4.55).

3 The second Intersessional Meeting of the Working Group on Greenhouse Gas Emissions from Ships (GHG-WG 2) agreed that the EEDI, as improved at its second session of the group, should apply as widely as possible.

4 However, GHG-WG 2 noted that the EEDI formula may not be able to apply to diesel-electric propulsion, turbine propulsion or hybrid propulsion systems (MEPC 59/4/2, paragraph 2.11).

5 In addition, GHG-WG 2 further agreed that for ships where the P_{AE} value calculated by the empirical formula to determine P_{AE} was significantly different from the total power used at normal seagoing, e.g., in cases of passenger ships, P_{AE} can be estimated by the total electric power (excluding propulsion) at normal sea going, to be given in the electric power table, divided by the conversion factor (0.9) from diesel engine power to electric power (MEPC 59/4/2, paragraph 2.18).

Objective

6 LNG carriers have traditionally been equipped with turbine propulsion systems, but recently, the use of diesel-electric propulsion system has been on the rise. However, as noted by GHG-WG 2, the EEDI calculation methods for LNG carriers adopting turbine propulsion systems or diesel-electric propulsion systems has not been established.

7 Accordingly, this document outlines the EEDI calculation methods according to different propulsion systems, provides the result of calculation using the data of recently constructed LNG carriers in service, and proposes a possible way forward based on the acquired outcome.

8 In addition, this document makes a comparison between the EEDI calculated using the empirical equation to determine P_{AE} and the normal maximum sea load (hereinafter refer to “NMSL”) and proposes a possible way forward based on the two result.

Calculation methods

9 To calculate the EEDI for LNG carriers adopting turbine propulsion system, the formula developed by GHG-WG 2 with the omission of unnecessary factors was used as follows:

$$\frac{\left(\sum_{i=1}^{nME} P_{ME(i)} C_{FME(i)} SFC_{ME(i)}\right) + \left(P_{AE} C_{FAE} SFC_{AE}\right)}{Capacity\ V_{ref}}$$

$$P_{ME(i)} = 0.75 \times \left(MCR_{MEi} - P_{PTOi}\right)$$

$$P_{AE(MCRME \geq 10,000kW)} = 0.025 \times \left(\sum_{i}^{nME} MCR_{MEi}\right) + 250 \qquad P_{AE(MCRME < 10,000kW)} = 0.05 \times \left(\sum_{i}^{nME} MCR_{MEi}\right)$$

.1 Where the output of steam turbine is used to calculate P_{ME} (case 1)
P_{ME} = 0.75 x Shaft power of steam turbine (MCR) (kW)
SFC_{ME} = Nominal Fuel Rate from “Heat Balance & Flow Diagram” (310 g/kW.h)
C_{FME} = Conversion Factor
P_{AE} = {(0.025 x Shaft power of steam turbine (MCR)) + 250} (kW)
SFC_{AE} = Nominal Fuel Rate from “Heat Balance & Flow Diagram” (310 g/kW.h)
C_{FAE} = Conversion Factor
Capacity = DWT, V_{REF}

10 To calculate the EEDI for LNG carriers adopting diesel-electric propulsion system, the formula developed by GHG-WG 2 with the omission of unnecessary factors was used as follows:

$$\frac{\left(P_{AE} C_{FAE} SFC_{AE}\right) + \left(\sum_{i=1}^{nPTI} P_{PTI(i)} C_{FAE} SFC_{AE}\right)}{Capacity\ V_{ref}}$$

$$P_{ME(i)} = 0.75 \times \left(MCR_{MEi} - P_{PTOi}\right)$$

$$P_{AE(MCRME \geq 10{,}000kW)} = 0.025 \times \left(\sum_{i}^{nME} MCR_{MEi}\right) + 250 \qquad P_{AE(MCRME < 10{,}000kW)} = 0.05 \times \left(\sum_{i}^{nME} MCR_{MEi}\right)$$

.1 Where the output of shaft motor is used to calculate P_{PTI} (case 2)
P_{PTI} = 0.75 x Rated power consumption of shaft motor (kW)
SFC_{AE} = SFC of A/E (g/kW.h)
C_{FAE} = Conversion Factor
P_{AE} = {(0.025 x Rated power consumption of shaft motor) + 250} (kW)
SFC_{AE} = SFC of A/E (g/kW.h)
C_{FAE} = Conversion Factor
Capacity = DWT, V_{REF}

11 To calculate the EEDI for LNG carriers adopting diesel propulsion systems, the formula developed by GHG-WG 2 with the omission of unnecessary factors was used as follows:

$$\frac{\left(\sum_{i=1}^{nME} P_{ME(i)} C_{FME(i)} SFC_{ME(i)}\right) + \left(P_{AE} C_{FAE} SFC_{AE}\right)}{Capacity\ V_{ref}}$$

$$P_{ME(i)} = 0.75 \times \left(MCR_{MEi} - P_{PTOi}\right)$$

$$P_{AE(MCRME \geq 10{,}000kW)} = 0.025 \times \left(\sum_{i}^{nME} MCR_{MEi}\right) + 250 \qquad P_{AE(MCRME < 10{,}000kW)} = 0.05 \times \left(\sum_{i}^{nME} MCR_{MEi}\right)$$

.1 Where the MCR of main engine is used in the calculation of P_{ME} (case 3)
P_{PTI} = 0.75 x Rated installed power (MCR) (kW)
SFC_{ME} = SFC of M/E (g/kW.h)
C_{FME} = Conversion Factor
P_{AE} = {(0.025 x Rated installed power (MCR)) + 250} (kW)
SFC_{AE} = SFC of A/E (g/kW.h)
C_{FAE} = Conversion Factor
Capacity = DWT, V_{REF}

Calculation results

12 To compare the EEDI according to different propulsion systems, the following five LNG carriers were investigated and the EEDI was calculated according to paragraphs 9, 10 and 11 above: (1) turbine propulsion system (2 ships), (2) diesel-electric propulsion system (2 ships), (3) diesel propulsion system (1 ship).

13 In addition, a comparison was made between the calculated EEDI using the empirical equation to determine P_{AE} and NMSL in order to assess the deviation between the two results.

14 The baseline values and the calculated EEDIs are attached as annex to this document together with a figure demonstrating the deviation among the ships equipped with turbine propulsion systems, diesel-electric propulsion systems and diesel propulsion systems.

Discussion and proposals

15 As can be seen from the Annex, the calculated EEDI for LNG carriers does not meet the baseline as proposed to MEPC 58 (refer to the MEPC 58/4/8, Denmark) and there is significant difference between different propulsion systems. Accordingly, the Republic of Korea proposes that the baseline methodology for LNG carriers should be re-considered.

16 Furthermore, when the calculated EEDI using the empirical equation to determine P_{AE} and the actual NMSL of electrical power table were compared, it was found that the EEDI calculated using NMSL was approximately 20% higher. This is due to the fact that the actual NMSL value is higher than P_{AE} calculated with the empirical equation. Accordingly, in calculating the EEDI of LNG carriers, the use of NMSL from actual electrical power tables is more desirable than calculating the P_{AE} value by the empirical equation.

17 On the other hand, according to the outcome of GHG-WG 2, DWT was used as capacity to calculate the EEDI in this document. However, tank volume should be used in the calculation of baseline values and therefore, special attention need to be paid to the fact that the EEDI could vary according to the capacity used. As a matter of fact, the EEDI calculated using the DWT becomes higher than by using the tank volume.

Action requested of the Committee

18 The Committee is invited to consider the information and proposal above and take action as appropriate.

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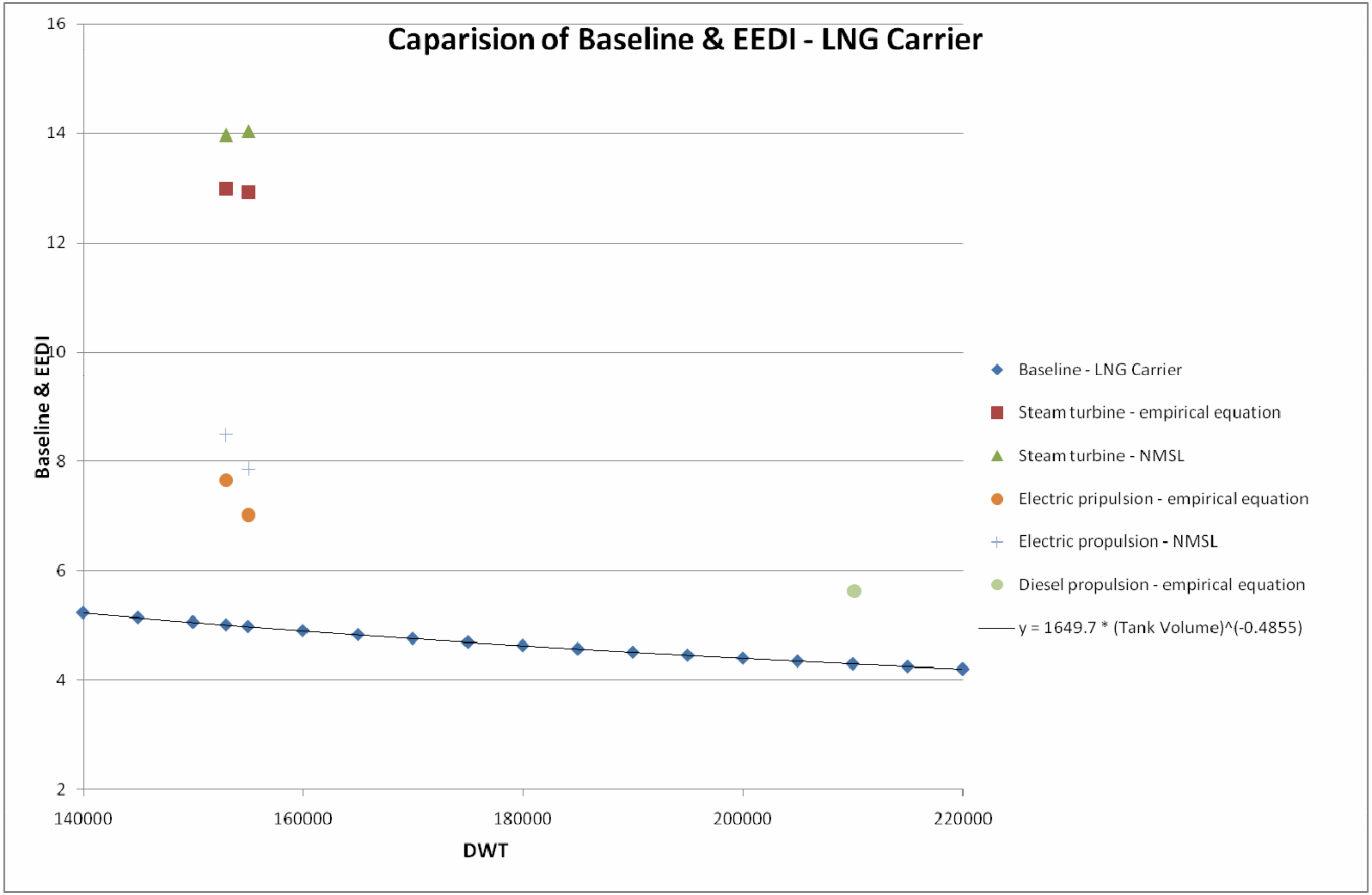
ANNEX

			Vessel				
			1 (Steam turbine)	2 (Steam turbine)	3 (Elec. propulsion)	4 (Elec. propulsion)	5 (Diesel propulsion)
Baseline value (MEPC 58/4/8)	$1649.7 \times (\text{Tank Volume})^{-0.4855}$		4.977051	5.008532	4.977051	5.008532	4.293785
Calculation of EEDI & Deviation ((Baseline – EEDI/ Baseline)	Case 1 (para. 9.1)	Using the empirical equation for P_{AE}	12.91833 +160%	12.98475 +159%			
		Using the NMSL	14.03241 +182%	13.96813 +179%			
	Case 2 (para. 10.1)	Using the empirical equation for P_{AE}			7.021006 +41%	7.664753 +53%	
		Using the NMSL			7.867842 +58%	8.485441 +69%	
	Case 3 (para. 11.1)	Using the empirical equation for P_{AE}					5.632119 +31%
		Using the NMSL					


Caparision of Baseline & EEDI - LNG Carrier
Baseline & EEDI
16
14
12
10
8
6
4
2
140000
160000
180000
200000
220000
DWT
Baseline - LNG Carrier
Steam turbine - empirical equation
Steam turbine - NMSL
Electric pripulsion - empirical equation
Electric propulsion - NMSL
Diesel propulsion - empirical equation
y = 1649.7 * (Tank Volume)^(-0.4855)