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PREVENTION OF AIR POLLUTION FROM SHIPS

Calculation procedures of the numerator of the new ship design CO_2 index

Submitted by Japan

SUMMARY

Executive summary:	This document provides practical procedures of calculating the numerator of design CO_2 index (the amount of CO_2 emission), in particular how to reflect the effects of energy saving devices in the calculation of the index, following the current draft guidelines of design CO_2 index (annex 5 to MEPC 58/4)
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1 and 7.3.1.3
Action to be taken:	Paragraph 4
Related document:	MEPC 58/4, paragraph 2.23 and annex 5

Introduction

1 This document provides comments on annex 5 to document MEPC 58/4 and is submitted in accordance with paragraph 4.10.5 of the Committees' Guidelines (MSC-MEPC.1/Circ.2).

2 The first Intersessional Meeting of the Working Group on Greeenhouse Gas Emissions from Ships, held in Oslo, agreed to the draft Guidelines on the Method of Calculation of the CO_2 Design Index for New Ships ("draft Index Guidelines", hereafter) including a draft formula and requested the Committee to consider the draft further (MEPC 58/4, paragraph 2.23 and annex 5, MEPC 58/4).

3 Japan supports the draft Index Guidelines in general, but there still remain some definitions of factors that are only conceptual and do not provide clear guidance for calculation. This may cause difficulties for stakeholders to set the factors in a consistent and uniform manner in their calculation of the index. In order to ensure uniform application, Japan has developed practical procedures for calculating the numerator of the design CO_2 index, which shows the

amount of CO_2 emission, in line with the present draft Index Guidelines. Particular attention was paid to how to properly reflect the effects of energy saving devices, e.g., turbo generators and exhaust gas economizers, in the numerator of the index. Such procedures, with an example of the calculation of the index for a particular sample ship, are given in the annex to this document.

Action requested of the Committee

4 The Committee is invited to consider practical procedures for calculating the numerator in the annex and take action as appropriate.

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ANNEX

CALCULATION PROCEDURES OF THE NUMERATOR OF THE NEW SHIP DESIGN CO_2 INDEX [1]

New ship design CO_2 index (annex 5 to MEPC 58/4)

$$Attained\ new\ ship\ design\ CO_2\ index = \frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{NME} C_{FMEi}\ SFC_{MEi}\ P_{MEi}\right) + \left(\prod_{k=1}^{L} f_k\right)\left(\sum_{i=1}^{NAE} C_{FAEi}\ SFC_{AEi}\ P_{AEi}\right)}{Capacity \times\ V_{ref} \times f_W}$$

Sample data used in the example of calculation

Ship type : VLCC 300,000DWT

Design Data: Main Engine: 13,600 kW (SFP: Shaft Force Power) x 2
SFC 170g/kWh (SFP)
Auxiliary Engine: 1,050 kW (SFP) x 2,
1,000 ekW (electric power) x 1(Turbo generator)
SFC 190g/kWh (SFP)
Total electric power consumption based on the anticipated electric consumption table:
900 ekW (normal seagoing in summer)
800 ekW (normal seagoing in winter)
1,600 ekW (ballast exchanging time in summer)
1,500 ekW (ballast exchanging time in winter)
1,700 ekW (loading/unloading)
130 ekW(emergency service time)
Boiler : 80,000 kg/h x 1, 6,000 kg/h (exhaust gas economizer)
Total steam consumption volume based on the steam consumption table:
6,000 kg/h (normal seagoing in summer)
6,500 kg/h (normal seagoing in winter)
76,500 kg/h (loading/unloading)

I. Calculation of main engine part

(1) f_j : f_j =1.0, except for ice-strengthened ship, etc., for which the IMO agrees on the necessity of the correction factor to account for special design features and defines such a factor as appropriate.

(2) C_{FME} : Choose the C_{FME} value as per fuel type in accordance with MEPC/Circ.471

(3) SFC_{ME}: Choose Uncorrected Specific Fuel Consumption value (g/kWh) at 75% of power/torque in the sheet 5/5 of the Parent Engine test report and test data, attached in the Technical File, determined by the paragraph 2.4.1 and Appendix 5 of the NOx Technical Code.

(4) P_{ME} : Use 75% of the rated power of EIAPP certificate[2].
In addition, the power of energy saving devices (e.g., shaft motor etc.) can be deducted further if the devices are installed to save the propulsion power.

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[1] Calculation procedures and an example of calculation provided in this annex, after due consideration, should be attached to the draft Index Guidelines, as reference information to assist uniform application of the Guidelines.

[2] V_{ref}, *Capacity* and P should be consistent with each other. There are several ways to determine P and V_{ref} : to use the designed power of main engine and the designed speed corresponding to such power as specified in the building contract, or, to use the fixed percentage, e.g., 75%, of rated power as the power of main engine, and the speed corresponding to such power. In order to enable fair comparison of ship performance, the definitions of those parameters should be carefully considered. The calculation herewith provided is just an example and should be revised according to the decision made on those definitions.

Calculation for the sample ship

I (1) f_j=1
(2) C_{FME1} = 3.1144 g CO_2 / g Fuel (HFO)
C_{FME2} = 3.1144 g CO_2 / g Fuel (HFO)
(3) SFC_{ME1} = 170 g/kWh
SFC_{ME2} = 170 g/kWh
(4) P_{ME1} = 13600 x 0.75 = 10,200 kW
P_{ME2} = 13600 x 0.75 = 10,200 kW

Subtotal: $\prod f_j \sum C_{FME} SFC_{ME} P_{ME}$ = 1 x 3.1144 x 170 x 10,200 x 2 = 10,800,739 g CO_2/h

II. Calculation of auxiliary engine part

(1) f_k : f_k =1.0, except for the ship which uses cargo gear, refer containers, etc., for which the IMO agrees on the necessity of the correction factor to account for special design features and defines such a factor as appropriate.

(2) C_{FAE} : Same as I.(2)

(3) SFC_{AE}

(a) **Auxiliary engine**

Choose Uncorrected Specific Fuel Consumption value (g/kWh) at 50% of power/torque in the sheet 5/5 of the Parent Engine test report and test data, attached in the Technical File, determined by the paragraph 2.4.1 and Appendix 5 of the NOx Technical Code.

(b) **Boilers**

SFC_{AE} is reciprocal number of the lower heating value as per fuel type (i.e, in case of residual fuel, 39.8 (kJ/g fuel), according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume2 Energy Table 1.2) multiplied by 0.9 as the boiler efficiency.

(4) P_{AE} :

(a) **Auxiliary engines**

STEP 1: Calculation of the required electric power for all auxiliary engines (ekW).
Select the maximum total electric power consumption value at normal sea going in the anticipated electric consumption table.

STEP 2: Calculation of the required electric power for auxiliary engines that consume fuel (kW).
Deduct the total of 75%[3] of the rating power of engines that do not consume fuel, e.g. turbo generators, from the value selected at STEP 1, assuming that the conversion efficiency from engine power to electricity is 0.9.

STEP 3: Calculation of each P_{AE}
Allocate P_{AE} of each engine so that the sum of P_{AE} corresponds to the value calculated at STEP 2.

(b) **Boilers**

STEP 4: Calculation of the required steam volume for all boilers (kg/h).
Select the maximum total steam consumption volume value at normal sea going in the anticipated steam consumption table.

STEP 5: Calculation of required steam volume for boilers that consume fuel (kg/h).
Deduct the total of 75%[3] of the steam consumption volume of boilers that do not consume fuel, e.g., exhaust gas economizers, from the value selected at STEP 4.

STEP 6: Allocate the required steam volume for each boiler (the same way as STEP 3).

STEP 7: Calculation of each P_{AE}.
Multiply the value obtained at STEP 6 by the latent heat (=2454.2kJ/kg-water (293K)) to get P_{AE} of boiler (kJ/h).

[3] The percentage figure (75%) may be modified, in line with the ratio of the rated power for the main engine.

Calculation for the sample ship

II (1) f_k = 1
(2) C_{FAE1} = 3.1144 g CO_2 / g Fuel (HFO)
C_{FAE2} = 3.1144 g CO_2 / g Fuel (HFO)
(3) (a) SFC_{AE1} = 190 g/kWh
SFC_{AE2} = 190 g/kWh
(b) SFC_{AE3} = 1/ (39.8 x 0.9) = 0.0279 g/kJ
(4) STEP1
Required electric power for all auxiliary engines = 900 ekW at normal sea going in summer
STEP 2
Required electric power for auxiliary engines consuming fuel
= 900 – 1000 (Turbo generator) x 0.75 = 150 ekW
Required shaft force power for auxiliary engines consuming fuel = 150/0.9=166.7 kW
STEP 3
P_{AE1} = 166.7 kW
P_{AE2} = 0 kW
STEP 4
Required steam volume for all boilers = 6,500 kg/h at normal sea going in winter
STEP 5
Required steam volume for boilers consuming fuel
= 6500 – 6000 (exhaust gas economizer) x 0.75 = 2,000 kg/h
STEP 6
Required steam volume for each boiler = 2,000 kg/h
STEP 7
P_{AE3}= 2,000 x 2454.2 = 4,908,400 kJ/h

Subtotal: $\prod f_k \sum C_{FAE} P_{AE} SFC_{AE}$
= 3.1144 x (166.7 x 190 + 4,908,400 x 0.0279) = 525,142 g CO_2/h

III The numerator of the new ship design CO_2 index

The numerator of the index = main engine part + auxiliary engine part
= 10,800,739 + 525,142= 11,325,881 g CO_2/h