

**ANNEX 9**

**RESOLUTION MEPC.364(79)**

**2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS**

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution from ships,

NOTING that regulation 22 (Attained Energy Efficiency Design Index (attained EEDI)) of MARPOL Annex VI, as amended, requires that the EEDI shall be calculated taking into account the guidelines developed by the Organization,

NOTING ALSO that the Committee adopted, at its seventy-third session, *2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships* (resolution MEPC.308(73)),

NOTING FURTHER that, at its seventy-fourth and seventy-sixth sessions, it adopted, by resolutions MEPC.322(74) and MEPC.332(76), respectively, amendments to the *2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*,

HAVING NOTED, at its seventy-ninth session, the need to further amend the *2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships* (resolution MEPC.308(73), as amended),

1 ADOPTS the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, as set out in the annex to the present resolution;

2 INVITES Administrations to implement the 2022 EEDI Calculation Guidelines when developing and enacting national laws which give force to, and implement provisions set forth in regulation 22 of MARPOL Annex VI, as amended;

3 REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the amendments to the attention of shipowners, ship operators, shipbuilders, ship designers and any other interested parties;

4 AGREES to keep these Guidelines, as amended, under review, in light of experience gained with their implementation;

5 AGREES that these Guidelines supersede the *2018 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships* (resolution MEPC.308(73), as amended by resolutions MEPC.322(74) and MEPC.332(76)).

## ANNEX

### 2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS

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## 1 Definitions

1.1 MARPOL means the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocols of 1978 and 1997 relating thereto, as amended.

1.2 For the purpose of these Guidelines, the definitions in chapter 4 of MARPOL Annex VI, as amended, apply.

## 2 Energy Efficiency Design Index (EEDI)

### 2.1 EEDI formula

The attained new ship Energy Efficiency Design Index (EEDI) is a measure of ships' energy efficiency (g/t · nm) and calculated by the following formula:

$$\frac{\left( \prod_{j=1}^n f_j \right) \left( \sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)} \right) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE} *) + \left( \left( \prod_{j=1}^n f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)} \right) C_{FAE} \cdot SFC_{AE} \right) - \left( \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} ** \right)}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m}$$

\* If part of the Normal Maximum Sea Load is provided by shaft generators,  $SFC_{ME}$  and  $C_{FME}$  may – for that part of the power – be used instead of  $SFC_{AE}$  and  $C_{FAE}$

\*\* In case of  $P_{PTI(i)} > 0$ , the average weighted value of  $(SFC_{ME} \cdot C_{FME})$  and  $(SFC_{AE} \cdot C_{FAE})$  to be used for calculation of  $P_{eff}$

**Note:** This formula may not be applicable to a ship having diesel electric propulsion, turbine propulsion or hybrid propulsion system, except for cruise passenger ships and LNG carriers.

### 2.2 Parameters

For the calculation of EEDI by the formula in paragraph 2.1, the following parameters apply.

#### 2.2.1 $C_F$ ; Conversion factor between fuel consumption and CO<sub>2</sub> emission

$C_F$  is a non-dimensional conversion factor between fuel consumption measured in g and CO<sub>2</sub> emission also measured in g based on carbon content. The subscripts  $ME(i)$  and  $AE(i)$  refer to the main and auxiliary engine(s) respectively.  $C_F$  corresponds to the fuel used when determining  $SFC$  listed in the applicable test report included in a Technical File as defined in paragraph 1.3.15 of the NO<sub>x</sub> Technical Code ("test report included in a NO<sub>x</sub> Technical File" hereafter). The value of  $C_F$  is as follows:

| Type of fuel                    | Reference                       | Lower calorific value (kJ/kg) | Carbon content | $C_F$ (t-CO <sub>2</sub> /t-Fuel) |
|---------------------------------|---------------------------------|-------------------------------|----------------|-----------------------------------|
| 1 Diesel/Gas Oil                | ISO 8217 Grades DMX through DMB | 42,700                        | 0.8744         | 3.206                             |
| 2 Light Fuel Oil (LFO)          | ISO 8217 Grades RMA through RMD | 41,200                        | 0.8594         | 3.151                             |
| 3 Heavy Fuel Oil (HFO)          | ISO 8217 Grades RME through RMK | 40,200                        | 0.8493         | 3.114                             |
| 4 Liquefied Petroleum Gas (LPG) | Propane                         | 46,300                        | 0.8182         | 3.000                             |
|                                 | Butane                          | 45,700                        | 0.8264         | 3.030                             |
| 5 Ethane                        |                                 | 46,400                        | 0.7989         | 2.927                             |

| Type of fuel                  | Reference | Lower calorific value (kJ/kg) | Carbon content | $C_F$<br>(t-CO <sub>2</sub> /t-Fuel) |
|-------------------------------|-----------|-------------------------------|----------------|--------------------------------------|
| 6 Liquefied Natural Gas (LNG) |           | 48,000                        | 0.7500         | 2.750                                |
| 7 Methanol                    |           | 19,900                        | 0.3750         | 1.375                                |
| 8 Ethanol                     |           | 26,800                        | 0.5217         | 1.913                                |

In the case of a ship equipped with a dual-fuel main or auxiliary engine, the  $C_F$  factor for gas fuel and the  $C_F$  factor for fuel oil should apply and be multiplied with the specific fuel oil consumption of each fuel at the relevant EEDI load point. Meanwhile, it should be identified whether gas fuel is regarded as the "primary fuel" in accordance with the formula below:

$$f_{DFgas} = \frac{\sum_{i=1}^{n_{total}} P_{total(i)}}{\sum_{i=1}^{n_{gasfuel}} P_{gasfuel(i)}} \times \frac{V_{gas} \times \rho_{gas} \times LCV_{gas} \times K_{gas}}{\left( \sum_{i=1}^{n_{liquid}} V_{liquid(i)} \times \rho_{liquid(i)} \times LCV_{liquid(i)} \times K_{liquid(i)} \right) + V_{gas} \times \rho_{gas} \times LCV_{gas} \times K_{gas}}$$

$$f_{DFliquid} = 1 - f_{DFgas}$$

where,

$f_{DFgas}$  is the fuel availability ratio of gas fuel corrected for the power ratio of gas engines to total engines;  $f_{DFgas}$  should not be greater than 1;

$V_{gas}$  is the total net gas fuel capacity on board in m<sup>3</sup>. If other arrangements, like exchangeable (specialized) LNG tank-containers and/or arrangements allowing frequent gas refuelling are used, the capacity of the whole LNG fuelling system should be used for  $V_{gas}$ . The boil-off rate (BOR) of gas cargo tanks can be calculated and included in  $V_{gas}$  if it is connected to the fuel gas supply system (FGSS);

$V_{liquid}$  is the total net liquid fuel capacity on board in m<sup>3</sup> of liquid fuel tanks permanently connected to the ship's fuel system. If one fuel tank is disconnected by permanent sealing valves,  $V_{liquid}$  of the fuel tank can be ignored;

$\rho_{gas}$  is the density of gas fuel in kg/m<sup>3</sup>;

$\rho_{liquid}$  is the density of each liquid fuel in kg/m<sup>3</sup>;

$LCV_{gas}$  is the low calorific value of gas fuel in kJ/kg;

$LCV_{liquid}$  is the low calorific value of liquid fuel in kJ/kg;

$K_{gas}$  is the filling rate for gas fuel tanks;

$K_{liquid}$  is the filling rate for liquid fuel tanks;

$P_{total}$  is the total installed engine power,  $P_{ME}$  and  $P_{AE}$  in kW;

$P_{gasfuel}$  is the dual-fuel engine installed power,  $P_{ME}$  and  $P_{AE}$  in kW;

- .1 If the total gas fuel capacity is at least 50% of the fuel capacity dedicated to the dual-fuel engines, namely  $f_{DFgas} \geq 0.5$ , then gas fuel is regarded as the "Primary fuel," and  $f_{DFgas} = 1$  and  $f_{DFliquid} = 0$  for each dual-fuel engine.

- .2 If  $f_{DFgas} < 0.5$ , gas fuel is not regarded as the "primary fuel." The  $C_F$  and  $SFC$  in the EEDI calculation for each dual-fuel engine (both main and auxiliary engines) should be calculated as the weighted average of  $C_F$  and  $SFC$  for liquid and gas mode, according to  $f_{DFgas}$  and  $f_{DFliquid}$ , such as the original item of  $P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}$  in the EEDI calculation is to be replaced by the formula below.

$$P_{ME(i)} \cdot (f_{DFgas(i)} \cdot (C_{FME \text{ pilot fuel}(i)} \cdot SFC_{ME \text{ pilot fuel}(i)} + C_{FME \text{ gas}(i)} \cdot SFC_{ME \text{ gas}(i)}) + f_{DFliquid(i)} \cdot C_{FME \text{ liquid}(i)} \cdot SFC_{ME \text{ liquid}(i)})$$

## 2.2.2 $V_{ref}$ ; Ship speed

$V_{ref}$  is the ship speed, measured in nautical miles per hour (knot), on deep water in the condition corresponding to the *capacity* as defined in paragraphs 2.2.3.1 and 2.2.3.3 (in the case of passenger ships and cruise passenger ships, this condition should be summer load draught as provided in paragraph 2.2.4) at the shaft power of the engine(s) as defined in paragraph 2.2.5 and assuming the weather is calm with no wind and no waves.

## 2.2.3 *Capacity*

*Capacity* is defined as follows.

- 2.2.3.1 For bulk carriers, tankers, gas carriers, LNG carriers, ro-ro cargo ships (vehicle carriers), ro-ro cargo ships, ro-ro passenger ships, general cargo ships, refrigerated cargo carrier and combination carriers, deadweight should be used as *capacity*.
- 2.2.3.2 For passenger ships and cruise passenger ships, gross tonnage in accordance with the International Convention of Tonnage Measurement of Ships 1969, annex I, regulation 3, should be used as *capacity*.
- 2.2.3.3 For container ships, 70% of the deadweight (DWT) should be used as *capacity*. EEDI values for container ships are calculated as follows:
- .1 attained EEDI is calculated in accordance with the EEDI formula using 70% deadweight for *capacity*;
- .2 estimated index value in the Guidelines for calculation of the reference line is calculated using 70% deadweight as:

$$\text{Estimated Index Value} = 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 215 \cdot P_{AE}}{70\% \text{DWT} \cdot V_{ref}}$$

- .3 parameters a and c for container ships in table 2 of regulation 24 of MARPOL Annex VI are determined by plotting the estimated index value against 100% deadweight, i.e. a = 174.22 and c = 0.201 were determined;
- .4 required EEDI for a new container ship is calculated using 100% deadweight as:

$$\text{Required EEDI} = (1-X/100) \cdot a \cdot 100\% \text{ deadweight}^{-c}$$

where X is the reduction factor (in percentage) in accordance with table 1 in regulation 24 of MARPOL Annex VI relating to the applicable phase and size of new container ship.

## 2.2.4 Deadweight

*Deadweight* means the difference in tonnes between the displacement of a ship in water of relative density of 1,025 kg/m<sup>3</sup> at the summer load draught and the lightweight of the ship. The summer load draught should be taken as the maximum summer draught as certified in the stability booklet approved by the Administration or an organization recognized by it.

## 2.2.5 $P$ ; Power of main and auxiliary engines

$P$  is the power of the main and auxiliary engines, measured in kW. The subscripts  $ME(i)$  and  $AE(i)$  refer to the main and auxiliary engine(s), respectively. The summation on  $i$  is for all engines with the number of engines ( $n_{ME}$ ) (see diagram in appendix 1).

### 2.2.5.1 $P_{ME(i)}$ ; Power of main engines

$P_{ME(i)}$  is 75% of the rated installed power (MCR<sup>1</sup>) for each main engine ( $i$ ).

For LNG carriers having diesel electric propulsion system,  $P_{ME(i)}$  should be calculated by the following formula:

$$P_{ME(i)} = 0.83 \times \frac{MPP_{Motor(i)}}{\eta_{(i)}}$$

Where:

$MPP_{Motor(i)}$  is the rated output of motor specified in the certified document.

$\eta_{(i)}$  is to be taken as the product of electrical efficiency of generator, transformer, converter and motor, taking into consideration the weighted average as necessary.

The electrical efficiency,  $\eta_{(i)}$ , should be taken as 91.3% for the purpose of calculating attained EEDI. Alternatively, if the value more than 91.3% is to be applied, the  $\eta_{(i)}$  should be obtained by measurement and verified by method approved by the verifier.

For LNG carriers having steam turbine propulsion systems,  $P_{ME(i)}$  is 83% of the rated installed power ( $MCR_{SteamTurbine}$ ) for each steam turbine ( $i$ ).

The influence of additional shaft power take off or shaft power take in is defined in the following paragraphs.

### 2.2.5.2 $P_{PTO(i)}$ ; Shaft generator

Where shaft generators are installed,  $P_{PTO(i)}$  is 75% of the rated electrical output power of each shaft generator. In the case of shaft generators installed with a steam turbine,  $P_{PTO(i)}$  is 83% of the rated electrical output power and the factor of 0.75 should be replaced by 0.83.

For calculating the effect of shaft generators, two options are available:

<sup>1</sup> The value of MCR specified on the EIAPP certificate should be used for calculation. If the main engines are not required to have an EIAPP certificate, the MCR on the nameplate should be used.

### Option 1:

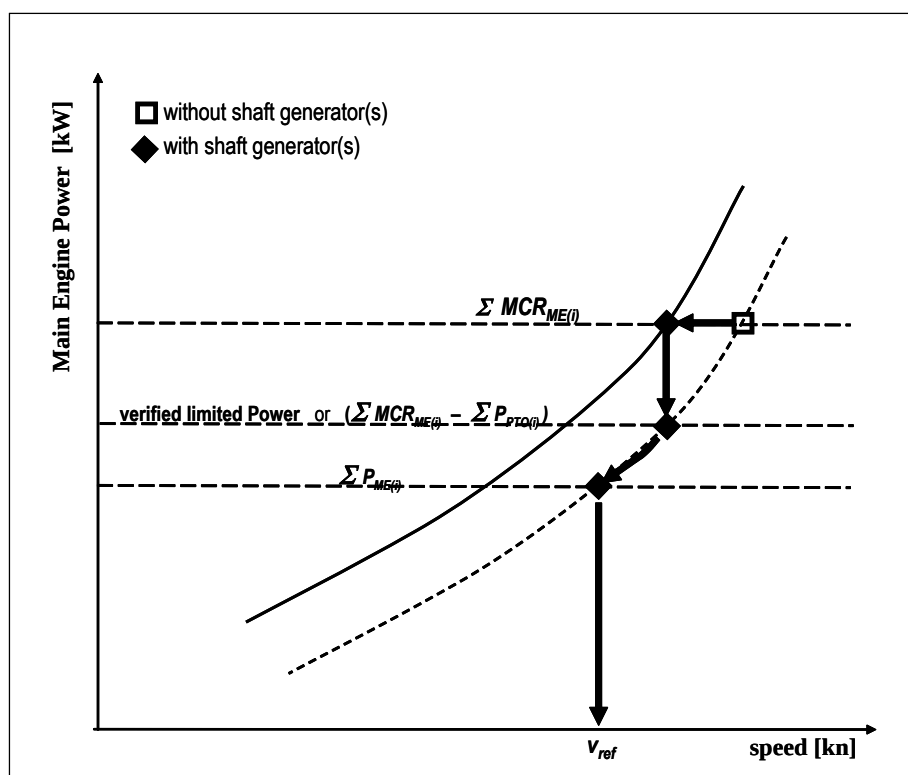
The maximum allowable  $P_{PTO(i)}$  deduction should be no more than  $P_{AE}/0.75$  with  $P_{AE}$  as defined in paragraph 2.2.5.6. For this case,  $\Sigma P_{ME(i)}$  is calculated as:

$$\sum_{i=1}^{nME} P_{ME(i)} = 0.75 \times \sum MCR_{ME(i)} - 0.75 \times \sum P_{PTO(i)} \quad \text{with } \sum P_{PTO(i)} \leq \frac{P_{AE}}{0.75}$$

or

### Option 2:

Where an engine is installed with a higher rated power output than that which the propulsion system is limited to by verified technical means, then the value of  $\Sigma P_{ME(i)}$  is 75% of that limited power for determining the reference speed,  $V_{ref}$  and for EEDI calculation. The following figure gives guidance for determination of  $\Sigma P_{ME(i)}$ :



### 2.2.5.3 $P_{PTI(i)}$ ; Shaft motor

Where shaft motors are installed,  $P_{PTI(i)}$  is 75% of the rated power consumption of each shaft motor divided by the weighted average efficiency of the generator(s), as follows:

$$\sum P_{PTI(i)} = \frac{\sum (0.75 \cdot P_{SM, \max(i)})}{\eta_{Gen}}$$

Where:

$P_{SM, \max(i)}$  is the rated power consumption of each shaft motor

$\eta_{Gen}$  is the weighted average efficiency of the generator(s)



Where shaft motors are installed with a steam turbine,  $P_{PTI(i)}$  is 83% of the rated power consumption and the factor of 0.75 should be replaced to 0.83.

The propulsion power at which  $V_{ref}$  is measured, is:

$$\sum P_{ME(i)} + \sum P_{PTI(i),Shaft}$$

Where:

$$\sum P_{PTI(i),Shaft} = \sum (0.75 \cdot P_{SM,max(i)} \cdot \eta_{PTI(i)})$$

$\eta_{PTI(i)}$  is the efficiency of each shaft motor installed

Where the total propulsion power as defined above is higher than 75% of the power the propulsion system is limited to by verified technical means, then 75% of the limited power is to be used as the total propulsion power for determining the reference speed,  $V_{ref}$  and for EEDI calculation.

In the case of combined PTI/PTO, the normal operational mode at sea will determine which of these is to be used in the calculation.

**Note:** The shaft motor's chain efficiency may be taken into consideration to account for the energy losses in the equipment from the switchboard to the shaft motor, if the chain efficiency of the shaft motor is given in a verified document.

#### 2.2.5.4 $P_{eff(i)}$ ; Innovative mechanical energy-efficient technology for main engine

$P_{eff(i)}$  is the output of the innovative mechanical energy-efficient technology for propulsion at 75% main engine power.

Mechanical recovered waste energy directly coupled to shafts need not be measured, since the effect of the technology is directly reflected in the  $V_{ref}$ .

In the case of a ship equipped with a number of engines, the  $C_F$  and  $SFC$  should be the power-weighted average of all the main engines.

In the case of a ship equipped with dual-fuel engine(s), the  $C_F$  and  $SFC$  should be calculated in accordance with paragraphs 2.2.1 and 2.2.7.

#### 2.2.5.5 $P_{AEff}$ ; Innovative mechanical energy-efficient technology for auxiliary engine

$P_{AEff(i)}$  is the auxiliary power reduction due to innovative electrical energy-efficient technology measured at  $P_{ME(i)}$ .

#### 2.2.5.6 $P_{AE}$ ; Auxiliary engine power

$P_{AE}$  is the required auxiliary engine power to supply normal maximum sea load including necessary power for propulsion machinery/systems and accommodation, e.g. main engine pumps, navigational systems and equipment and living on board, but excluding the power not for propulsion machinery/systems, e.g. thrusters, cargo pumps, cargo gear, ballast pumps, maintaining cargo, e.g. reefers and cargo hold fans, in the condition where the ship engaged in voyage at the speed ( $V_{ref}$ ) under the condition as mentioned in paragraph 2.2.2.

2.2.5.6.1 For ships whose total propulsion power ( $\sum MCR_{ME(i)} + \frac{\sum P_{PTI(i)}}{0.75}$ ) is 10,000 kW or above,  $P_{AE}$  is defined as:

$$P_{AE (\sum MCR_{ME(i)} \geq 10,000 \text{ kW})} = \left( 0.025 \times \left( \sum_{i=1}^{nME} MCR_{ME(i)} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75} \right) \right) + 250$$

2.2.5.6.2 For ships whose total propulsion power ( $\sum MCR_{ME(i)} + \frac{\sum P_{PTI(i)}}{0.75}$ ) is below 10,000 kW,  $P_{AE}$  is defined as:

$$P_{AE (\sum MCR_{ME(i)} < 10,000 \text{ kW})} = \left( 0.05 \times \left( \sum_{i=1}^{nME} MCR_{ME(i)} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75} \right) \right)$$

2.2.5.6.3 For LNG carriers with a reliquefaction system or compressor(s), designed to be used in normal operation and essential for maintaining the LNG cargo tank pressure below the maximum allowable relief valve setting of a cargo tank in normal operation, the following terms should be added to above  $P_{AE}$  formula in accordance with 2.2.5.6.3.1, 2.2.5.6.3.2 or 2.2.5.6.3.3 as below:

.1 For ships having reliquefaction system:

$$+ \text{CargoTankCapacity}_{LNG} \times BOR \times COP_{reliquefy} \times R_{reliquefy}$$

Where:

$\text{CargoTankCapacity}_{LNG}$  is the LNG Cargo Tank Capacity in m<sup>3</sup>.

$BOR$  is the design rate of boil-off gas of entire ship per day, which is specified in the specification of the building contract.

$COP_{reliquefy}$  is the coefficient of design power performance for reliquefying boil-off gas per unit volume, as follows:

$$COP_{reliquefy} = \frac{425(\text{kg/m}^3) \times 511(\text{kJ/kg})}{24(\text{h}) \times 3600(\text{sec}) \times COP_{cooling}}$$

$COP_{cooling}$  is the coefficient of design performance of reliquefaction and 0.166 should be used. Another value calculated by the manufacturer and verified by the Administration or an organization recognized by the Administration may be used.

$R_{reliquefy}$  is the ratio of boil-off gas (BOG) to be reliquefied to entire BOG, calculated as follows:

$$R_{reliquefy} = \frac{BOG_{reliquefy}}{BOG_{total}}$$

- .2 For LNG carriers with direct diesel driven propulsion system or diesel electric propulsion system, having compressor(s) which are used for supplying high-pressured gas derived from boil-off gas to the installed engines (typically intended for 2-stroke dual-fuel engines):

$$+ COP_{comp} \times \sum_{i=1}^{nME} SFC_{ME(i), gasmode} \times \frac{P_{ME(i)}}{1000}$$

Where:

$COP_{comp}$  is the design power performance of compressor and 0.33 (kWh/kg) should be used. Another value calculated by the manufacturer and verified by the Administration or an organization recognized by the Administration may be used.

- .3 For LNG carriers with direct diesel driven propulsion system or diesel electric propulsion system, having compressor(s) which are used for supplying low-pressured gas derived from boil-off gas to the installed engines (typically intended for 4-stroke dual-fuel engines):

$$+ 0.02 \times \sum_{i=1}^{nME} P_{ME(i)}^2$$

2.2.5.6.4 For LNG carriers having diesel electric propulsion system,  $MPP_{Motor(i)}$  should be used instead of  $MCR_{ME(i)}$  for  $P_{AE}$  calculation.

2.2.5.6.5 For LNG carriers having a steam turbine propulsion system and whose electric power is primarily supplied by turbine generator closely integrated into the steam and feed water systems,  $P_{AE}$  may be treated as 0(zero) instead of taking into account electric load in calculating  $SFC_{SteamTurbine}$ .

## 2.2.5.7 Use of electric power table

For ships where the  $P_{AE}$  value calculated by paragraphs 2.2.5.6.1 to 2.2.5.6.3 is significantly different from the total power used at normal seagoing, e.g. in cases of passenger ships (see NOTE under the formula of EEDI), the  $P_{AE}$  value should be estimated by the consumed electric power (excluding propulsion) in conditions when the ship is engaged in a voyage at reference speed ( $V_{ref}$ ) as given in the electric power table,<sup>3</sup> divided by the average efficiency of the generator(s) weighted by power (see appendix 2).

<sup>2</sup> With regard to the factor of 0.02, it is assumed that the additional energy needed to compress BOG for supplying to a 4-stroke dual fuel engine is approximately equal to 2% of  $P_{ME}$ , compared to the energy needed to compress BOG for supplying to a steam turbine.

<sup>3</sup> The electric power table should be examined and validated by the verifier. Where ambient conditions affect any electrical load in the power table, such as that for heating ventilation and air conditioning systems, the contractual ambient conditions leading to the maximum design electrical load of the installed system for the ship in general should apply.

## **2.2.6 Consistency of parameters $V_{ref}$ , Capacity and $P$**

$V_{ref}$ , Capacity and  $P$  should be consistent with each other. As for LNG carries having diesel electric or steam turbine propulsion systems,  $V_{ref}$  is the relevant speed at 83% of  $MPP_{Motor}$  or  $MCR_{SteamTurbine}$  respectively.

## **2.2.7 SFC; Certified specific fuel consumption**

$SFC$  is the certified specific fuel consumption, measured in g/kWh, of the engines or steam turbines.

### **2.2.7.1 SFC for main and auxiliary engines**

The subscripts  $ME(i)$  and  $AE(i)$  refer to the main and auxiliary engine(s), respectively. For engines certified to the E2 or E3 test cycles of the NO<sub>x</sub> Technical Code 2008, the engine specific fuel consumption ( $SFC_{ME(i)}$ ) is that recorded in the test report included in a NO<sub>x</sub> Technical File for the engine(s) at 75% of MCR power of its torque rating. For engines certified to the D2 or C1 test cycles of the NO<sub>x</sub> Technical Code 2008, the engine specific fuel consumption ( $SFC_{AE(i)}$ ) is that recorded on the test report included in a NO<sub>x</sub> Technical File at the engine(s) 50% of MCR power or torque rating. If gas fuel is used as primary fuel in accordance with paragraph 4.2.3 of the *Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*,  $SFC$  in gas mode should be used. Where installed engines have no approved NO<sub>x</sub> Technical File tested in gas mode, the  $SFC$  of gas mode should be submitted by the manufacturer and confirmed by the verifier.

The  $SFC$  should be corrected to the value corresponding to the ISO standard reference conditions using the standard lower calorific value of the fuel oil (42,700kJ/kg), referring to ISO 15550:2002 and ISO 3046-1:2002.

For ships where the  $P_{AE}$  value calculated by paragraphs 2.2.5.6.1 to 2.2.5.6.3 is significantly different from the total power used at normal seagoing, e.g. conventional passenger ships, the specific fuel consumption ( $SFC_{AE}$ ) of the auxiliary generators is that recorded in the test report included in a NO<sub>x</sub> Technical File for the engine(s) at 75% of MCR power of its torque rating.

$SFC_{AE}$  is the power-weighted average among  $SFC_{AE(i)}$  of the respective engines  $i$ .

For those engines which do not have a test report included in a NO<sub>x</sub> Technical File because their power is below 130 kW, the  $SFC$  specified by the manufacturer and endorsed by a competent authority should be used.

At the design stage, in case of unavailability of test report in the NO<sub>x</sub> file, the  $SFC$  specified by the manufacturer and endorsed by a competent authority should be used.

For LNG driven engines of which  $SFC$  is measured in kJ/kWh, the  $SFC$  value should be corrected to g/kWh using the standard lower calorific value of the LNG (48,000 kJ/kg), referring to the 2006 IPCC Guidelines.

Reference lower calorific values of additional fuels are given in the table in paragraph 2.2.1 of these Guidelines. The reference lower calorific value corresponding to the conversion factor of the respective fuel should be used for calculation.

### 2.2.7.2 SFC for steam turbines ( $SFC_{SteamTurbine}$ )

The  $SFC_{SteamTurbine}$  should be calculated by the manufacturer and verified by the Administration or an organization recognized by the Administration as follows:

$$SFC_{SteamTurbine} = \frac{FuelConsumption}{\sum_{i=1}^{nME} P_{ME(i)}}$$

Where:

- .1 *Fuel consumption* is fuel consumption of boiler per hour (g/h). For ships whose electric power is primarily supplied by turbine generator closely integrated into the steam and feed water systems, not only  $P_{ME}$  but also *electric loads* corresponding to paragraph 2.2.5.6 should be taken into account.
- .2 The  $SFC$  should be corrected to the value of LNG using the standard lower calorific value of the LNG (48,000 kJ/kg) at SNAME Condition (condition standard; air temperature 24°C, inlet temperature of fan 38°C, seawater temperature 24°C).
- .3 In this correction, the difference of the boiler efficiency based on lower calorific value between test fuel and LNG should be taken into account.

### 2.2.8 $f_j$ ; Ship-specific design elements

$f_j$  is a correction factor to account for ship-specific design elements:

#### 2.2.8.1 Power correction factor for ice-classed ships

The power correction factor,  $f_j$ , for ice-classed ships should be taken as the greater value of  $f_{j0}$  and  $f_{j,min}$  as tabulated in table 1 but not greater than  $f_{j,max} = 1.0$ .

For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7.<sup>4</sup>

**Table 1: Correction factor for power  $f_j$  for ice-classed ships**

| Ship type               | $f_{j0}$                                                         | $f_{j,min}$ depending on the ice class |                             |                             |                             |
|-------------------------|------------------------------------------------------------------|----------------------------------------|-----------------------------|-----------------------------|-----------------------------|
|                         |                                                                  | IA Super                               | IA                          | IB                          | IC                          |
| Tanker                  | $\frac{17.444 \cdot DWT^{0.5766}}{\sum_{i=1}^{nME} MCR_{ME(i)}}$ | $0.2488 \cdot DWT^{0.0903}$            | $0.4541 \cdot DWT^{0.0524}$ | $0.7783 \cdot DWT^{0.0145}$ | $0.8741 \cdot DWT^{0.0079}$ |
| Bulk carrier            | $\frac{17.207 \cdot DWT^{0.5705}}{\sum_{i=1}^{nME} MCR_{ME(i)}}$ | $0.2515 \cdot DWT^{0.0851}$            | $0.3918 \cdot DWT^{0.0556}$ | $0.8075 \cdot DWT^{0.0071}$ | $0.8573 \cdot DWT^{0.0087}$ |
| General cargo ship      | $\frac{1.974 \cdot DWT^{0.7987}}{\sum_{i=1}^{nME} MCR_{ME(i)}}$  | $0.1381 \cdot DWT^{0.1435}$            | $0.1574 \cdot DWT^{0.144}$  | $0.3256 \cdot DWT^{0.0922}$ | $0.4966 \cdot DWT^{0.0583}$ |
| Refrigerated cargo ship | $\frac{5.598 \cdot DWT^{0.696}}{\sum_{i=1}^{nME} MCR_{ME(i)}}$   | $0.5254 \cdot DWT^{0.0357}$            | $0.6325 \cdot DWT^{0.0278}$ | $0.7670 \cdot DWT^{0.0159}$ | $0.8918 \cdot DWT^{0.0079}$ |

<sup>4</sup> HELCOM Recommendation 25/7 may be found at <http://www.helcom.fi>

Alternatively, if an ice-class ship is designed and constructed based on an open water ship with the same shape and size of hull with EEDI certification, the power correction factor,  $f_j$ , for ice-classed ships can be calculated by using propulsion power of the new ice-class ship required by ice-class regulations,  $P_{ice\ class}$ , and the existing open water ship,  $P_{ow}$ , as follows:

$$f_j = \frac{P_{ow}}{P_{ice\ class}}$$

In this case,  $V_{ref}$  should be measured at the shaft power of the engine(s) installed on the existing open water ship as defined in paragraph 2.2.5.

### 2.2.8.2 Power correction factor for shuttle tankers with propulsion redundancy

The power correction factor  $f_j$ , for shuttle tankers with propulsion redundancy should be  $f_j = 0.77$ . This correction factors applies to shuttle tankers with propulsion redundancy between 80,000 and 160,000 dwt. Shuttle tankers with propulsion redundancy are tankers used for loading crude oil from offshore installations equipped with dual-engine and twin-propellers need to meet the requirements for dynamic positioning and redundancy propulsion class notation.

### 2.2.8.3 Correction factor for ro-ro cargo and ro-ro passenger ships ( $f_{jRoRo}$ )

For ro-ro cargo and ro-ro passenger ships  $f_{jRoRo}$  is calculated as follows:

$$f_{jRoRo} = \frac{1}{F_{n_L}^\alpha \cdot \left(\frac{L_{pp}}{B_s}\right)^\beta \cdot \left(\frac{B_s}{d_s}\right)^\gamma \cdot \left(\frac{L_{pp}}{\nabla^{1/3}}\right)^\delta} \quad ; \quad \text{If } f_{jRoRo} > 1 \text{ then } f_j = 1$$

where the Froude number,  $F_{n_L}$ , is defined as:

$$F_{n_L} = \frac{0.5144 \cdot V_{ref}}{\sqrt{L_{pp} \cdot g}}$$

and the exponents  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  are defined as follows:

| Ship type            | Exponent: |         |          |          |
|----------------------|-----------|---------|----------|----------|
|                      | $\alpha$  | $\beta$ | $\gamma$ | $\delta$ |
| Ro-ro cargo ship     | 2.00      | 0.50    | 0.75     | 1.00     |
| Ro-ro passenger ship | 2.50      | 0.75    | 0.75     | 1.00     |

#### 2.2.8.4 Correction factor for general cargo ships

The factor  $f_j$  for general cargo ships is calculated as follows:

$$f_j = \frac{0.174}{Fn_{\nabla}^{2.3} \cdot C_b^{0.3}} \quad ; \quad \text{If } f_j > 1 \text{ then } f_j = 1$$

Where

$$Fn_{\nabla} = \frac{0.5144 \cdot V_{ref}}{\sqrt{g \cdot \nabla^{\frac{1}{3}}}} \quad ; \quad \text{If } Fn_{\nabla} > 0.6 \text{ then } Fn_{\nabla} = 0.6$$

and

$$C_b = \frac{\nabla}{L_{pp} \cdot B_s \cdot d_s}$$

#### 2.2.8.5 Correction factor for other ship types

For other ship types,  $f_j$  should be taken as 1.0.

#### 2.2.9 $f_w$ ; Factor for speed reduction at sea

$f_w$  is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g. Beaufort Scale 6), and is determined as follows:

2.2.9.1 for the attained EEDI calculated under regulations 22 and 24 of MARPOL Annex VI,  $f_w$  is 1.00;

2.2.9.2 when  $f_w$  is calculated according to the sub-paragraph 2.2.9.2.1 or 2.2.9.2.2 below, the value for attained EEDI calculated by the formula in paragraph 2.1 using the obtained  $f_w$  should be referred to as "*attained EEDI<sub>weather</sub>*";

2.2.9.2.1  $f_w$  can be determined by conducting the ship-specific simulation on its performance at representative sea conditions. The simulation methodology should be based on the Guidelines developed by the Organization<sup>5</sup> and the method and outcome for an individual ship should be verified by the Administration or an organization recognized by the Administration; and

2.2.9.2.2 In cases where a simulation is not conducted,  $f_w$  should be taken from the "Standard  $f_w$ " table/curve. A "Standard  $f_w$ " table/curve is provided in the Guidelines<sup>5</sup> for each ship type defined in regulation 2 of MARPOL Annex VI, and expressed as a function of capacity (e.g. deadweight). The "Standard  $f_w$ " table/curve is based on data of actual speed reduction of as many existing ships as possible under the representative sea condition.

2.2.9.3  $f_w$  and *attained EEDI<sub>weather</sub>*, if calculated, with the representative sea conditions under which those values are determined, should be indicated in the EEDI Technical File to distinguish it from the attained EEDI calculated under regulations 22 and 24 of MARPOL Annex VI.

<sup>5</sup> Refer to *Interim guidelines for the calculation of the coefficient  $f_w$  for decrease in ship speed in a representative sea condition for trial use*, approved by the Organization and circulated by MEPC.1/Circ.796.

## **2.2.10 $f_{eff(i)}$ ; Factor of each innovative energy efficiency technology**

$f_{eff(i)}$  is the availability factor of each innovative energy efficiency technology.  $f_{eff(i)}$  for waste energy recovery system should be one (1.0)<sup>6</sup>.

## **2.2.11 $f_i$ ; Capacity factor for technical/regulatory limitation on capacity**

$f_i$  is the capacity factor for any technical/regulatory limitation on capacity, and should be assumed to be one (1.0) if no necessity of the factor is granted.

### **2.2.11.1 Capacity correction factor for ice-classed ships**

The capacity correction factor,  $f_i$ , for ice-classed ships having DWT as the measure of capacity should be calculated as follows:

$$f_i = f_{i(ice\ class)} \cdot f_{iC_b},$$

where  $f_{i(ice\ class)}$  is the capacity correction factor for ice-strengthening of the ship, which can be obtained from Table 2 and  $f_{iC_b}$  is the capacity correction factor for improved ice-going capability, which should not be less than 1.0 and which should be calculated as follows:

$$f_{iC_b} = \frac{C_{b\ reference\ design}}{C_b},$$

where  $C_{b\ reference\ design}$  is the average block coefficient for the ship type, which can be obtained from Table 3 for bulk carriers, tankers and general cargo ships, and  $C_b$  is the block coefficient of the ship. For ship types other than bulk carriers, tankers and general cargo ships,

$$f_{iC_b} = 1.0.$$

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<sup>6</sup> EEDI calculation should be based on the normal seagoing condition outside Emission Control Areas designated under regulation 13.6 of MARPOL Annex VI.



**Table 2: Capacity correction factor for ice-strengthening of the hull**

| Ice class <sup>7</sup> | $f_{i(ice\ class)}$               |
|------------------------|-----------------------------------|
| IC                     | $f_{i(IC)} = 1.0041 + 58.5/DWT$   |
| IB                     | $f_{i(IB)} = 1.0067 + 62.7/DWT$   |
| IA                     | $f_{i(IA)} = 1.0099 + 95.1/DWT$   |
| IA Super               | $f_{i(IAS)} = 1.0151 + 228.7/DWT$ |

**Table 3: Average block coefficients  $C_{b\ reference\ design}$  for bulk carriers, tankers and general cargo ships**

|                    | Size categories  |                     |                     |                     |                  |
|--------------------|------------------|---------------------|---------------------|---------------------|------------------|
| Ship type          | below 10,000 DWT | 10,000 – 25,000 DWT | 25,000 – 55,000 DWT | 55,000 – 75,000 DWT | above 75,000 DWT |
| Bulk carrier       | 0.78             | 0.80                | 0.82                | 0.86                | 0.86             |
| Tanker             | 0.78             | 0.78                | 0.80                | 0.83                | 0.83             |
| General cargo ship | 0.80             |                     |                     |                     |                  |

Alternatively, the capacity correction factor for ice-strengthening of the ship ( $f_{i(ice\ class)}$ ) can be calculated by using the formula given for the ship-specific voluntary enhancement correction coefficient ( $f_{i\ VSE}$ ) in paragraph 2.2.11.2. This formula can also be used for other ice classes than those given in Table 2.

### 2.2.11.2 $f_{i\ VSE}$ <sup>8</sup> ; Ship-specific voluntary structural enhancement

$f_{i\ VSE}$  for ship-specific voluntary structural enhancement is expressed by the following formula:

$$f_{i\ VSE} = \frac{DWT_{reference\ design}}{DWT_{enhanced\ design}}$$

where:

$$DWT_{reference\ design} = \Delta_{ship} - lightweight_{reference\ design}$$

$$DWT_{enhanced\ design} = \Delta_{ship} - lightweight_{enhanced\ design}$$

For this calculation the same displacement ( $\Delta$ ) for reference and enhanced design should be taken.

DWT before enhancements ( $DWT_{reference\ design}$ ) is the deadweight prior to application of the structural enhancements. DWT after enhancements ( $DWT_{enhanced\ design}$ ) is the deadweight following the application of voluntary structural enhancement. A change of material (e.g. from

<sup>7</sup> For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7, which can be found at <http://www.helcom.fi>

<sup>8</sup> Structural and/or additional class notations such as, but not limited to, "strengthened for discharge with grabs" and "strengthened bottom for loading/unloading aground", which result in a loss of deadweight of the ship, are also seen as examples of "voluntary structural enhancements".

aluminium alloy to steel) between reference design and enhanced design should not be allowed for the  $f_{iVSE}$  calculation. A change in grade of the same material (e.g. in steel type, grades, properties and condition) should also not be allowed.

In each case, two sets of structural plans of the ship should be submitted to the verifier for assessment: one set for the ship without voluntary structural enhancement; the other set for the same ship with voluntary structural enhancement (alternatively, one set of structural plans of the reference design with annotations of voluntary structural enhancement should also be acceptable). Both sets of structural plans should comply with the applicable regulations for the ship type and intended trade.

### **2.2.11.3 $f_{iCSR}$ ; Ships under the Common Structural Rules (CSR)**

For bulk carriers and oil tankers, built in accordance with the Common Structural Rules (CSR) of the classification societies and assigned the class notation CSR, the following capacity correction factor  $f_{iCSR}$  should apply:

$$f_{iCSR} = 1 + (0.08 \cdot LWT_{CSR} / DWT_{CSR})$$

Where  $DWT_{CSR}$  is the deadweight determined by paragraph 2.2.4 and  $LWT_{CSR}$  is the light weight of the ship.

### **2.2.11.4 $f_i$ for other ship types**

For other ship types,  $f_i$  should be taken as one (1.0).

### **2.2.12 $f_c$ ; Cubic capacity correction factor**

$f_c$  is the cubic capacity correction factor and should be assumed to be one (1.0) if no necessity of the factor is granted.

#### **2.2.12.1 $f_c$ for chemical tankers**

For chemical tankers, as defined in regulation 1.16.1 of MARPOL Annex II, the following cubic capacity correction factor  $f_c$  should apply:

$$f_c = R^{-0.7} - 0.014, \text{ where } R \text{ is less than } 0.98$$

or

$$f_c = 1.000, \text{ where } R \text{ is } 0.98 \text{ and above;}$$

where:  $R$  is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.2.4 divided by the total cubic capacity of the cargo tanks of the ship ( $m^3$ ).

#### **2.2.12.2 $f_c$ for gas carriers**

for gas carriers having direct diesel driven propulsion system constructed or adapted and used for the carriage in bulk of liquefied natural gas, the following cubic capacity correction factor  $f_{cLNG}$  should apply:

$$f_{cLNG} = R^{-0.56}$$

where:  $R$  is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.2.4 divided by the total cubic capacity of the cargo tanks of the ship ( $m^3$ ).

**Note:** This factor is applicable to LNG carriers defined as gas carriers in regulation 2.2.14 of MARPOL Annex VI and should not be applied to LNG carriers defined in regulation 2.2.16 of MARPOL Annex VI.

### 2.2.12.3 $f_c$ for ro-ro passenger ships ( $f_{cRoPax}$ )

For ro-ro passenger ships having a DWT/GT-ratio of less than 0.25, the following cubic capacity correction factor,  $f_{cRoPax}$ , should apply:

$$f_{cRoPax} = \left( \frac{(DWT/GT)}{0.25} \right)^{-0.8}$$

Where DWT is the Capacity and GT is the gross tonnage in accordance with the International Convention of Tonnage Measurement of Ships 1969, annex I, regulation 3.

### 2.2.12.4 $f_c$ for bulk carriers having $R$ of less than 0.55 ( $f_{c \text{ bulk carriers designed to carry light cargoes}}$ )

For bulk carriers having  $R$  of less than 0.55 (e.g. woodchip carriers), the following cubic capacity correction factor,  $f_{c \text{ bulk carriers designed to carry light cargoes}}$ , should apply:

$$f_{c \text{ bulk carriers designed to carry light cargoes}} = R^{-0.15}$$

where  $R$  is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.2.4 divided by the total cubic capacity of the cargo holds of the ship (m<sup>3</sup>).

### 2.2.13 $L_{pp}$ ; Length between perpendiculars

Length between perpendiculars,  $L_{pp}$ , means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that were greater. In ships designed with a rake of keel the waterline on which this length is measured should be parallel to the designed waterline.  $L_{pp}$  should be measured in metres.

### 2.2.14 $f_l$ ; Factor for general cargo ships equipped with cranes and cargo-related gear

$f_l$  is the factor for general cargo ships equipped with cranes and other cargo-related gear to compensate in a loss of deadweight of the ship.

$$f_l = f_{cranes} \cdot f_{sideloader} \cdot f_{ro-ro}$$

$$\begin{aligned} f_{cranes} &= 1 && \text{If no cranes are present} \\ f_{sideloader} &= 1 && \text{If no side loaders are present} \\ f_{ro-ro} &= 1 && \text{If no ro-ro ramp is present} \end{aligned}$$

Definition of  $f_{cranes}$  :

$$f_{cranes} = 1 + \frac{\sum_{n=1}^n (0.0519 \cdot SWL_n \cdot Reach_n + 32.11)}{Capacity}$$

where:

|       |   |                                                                        |
|-------|---|------------------------------------------------------------------------|
| SWL   | = | Safe Working Load, as specified by crane manufacturer in metric tonnes |
| Reach | = | Reach at which the Safe Working Load can be applied in metres          |
| N     | = | Number of cranes                                                       |

For other cargo gear such as side loaders and ro-ro ramps, the factor should be defined as follows:

$$f_{\text{sideloader}} = \frac{\text{Capacity}_{\text{No sideloaders}}}{\text{Capacity}_{\text{sideloaders}}}$$

$$f_{\text{RoRo}} = \frac{\text{Capacity}_{\text{No RoRo}}}{\text{Capacity}_{\text{RoRo}}}$$

The weight of the side loaders and ro-ro ramps should be based on a direct calculation, by analogy with the calculations made for factor  $f_{\text{ivse}}$ .

#### **2.2.15 $d_s$ ; Summer load line draught**

Summer load line draught,  $d_s$ , is the vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to the summer freeboard draught to be assigned to the ship.

In the case of a new ship with multiple load line certificates or with a load line certificate containing multiple summer load lines, the maximum summer draught should be used to calculate and verify the required and attained EEDI. For ships that may have previously received multiple EEDI assessments for several deadweights that correspond to multiple load lines, all those EEDI assessments should remain valid.

#### **2.2.16 $B_s$ ; Breadth**

Breadth,  $B_s$ , is the greatest moulded breadth of the ship, in metres, at or below the load line draught,  $d_s$ .

#### **2.2.17 $\nabla$ ; Volumetric displacement**

Volumetric displacement,  $\nabla$ , in cubic metres ( $\text{m}^3$ ), is the volume of the moulded displacement of the ship, excluding appendages, in a ship with a metal shell, and is the volume of displacement to the outer surface of the hull in a ship with a shell of any other material, both taken at the summer load line draught,  $d_s$ , as stated in the approved stability booklet/loading manual.

#### **2.2.18 $g$ ; Gravitational acceleration**

$g$  is the gravitational acceleration,  $9.81\text{m/s}^2$ .

#### **2.2.19 $f_m$ ; Factor for ice-classed ships having IA Super and IA**

For ice-classed ships having IA Super or IA, the following factor,  $f_m$ , should apply:

$$f_m = 1.05$$

For further information on approximate correspondence between ice classes, see HELCOM Recommendation 25/7<sup>9</sup>.

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<sup>9</sup> HELCOM Recommendation 25/7 may be found at <http://www.helcom.fi>

### **3 Mandatory reporting of attained EEDI values and related information**

3.1 In accordance with regulation 22.3 of MARPOL Annex VI, for each ship subject to regulation 24, the Administration or any organization duly authorized by it shall report the required and attained EEDI values and relevant information taking into account these Guidelines via electronic communication.

3.2 Information to be reported are as follows:

- .1 applicable EEDI phase (e.g. Phase 1, Phase 2);
- .2 identification number (IMO Secretariat use only);
- .3 ship type;
- .4 common commercial size reference<sup>10</sup> (see Note (3) in appendix 5 to these Guidelines), if available;
- .5 DWT or GT (as appropriate);
- .6 year of delivery;
- .7 required EEDI value;
- .8 attained EEDI value;
- .9 dimensional parameters (length  $L_{pp}$  (m), breadth  $B_s$  (m), and draught (m));
- .10  $V_{ref}$  (knots) and  $P_{ME}$  (kW);
- .11 use of innovative technologies (4th and 5th terms in the EEDI equation, if applicable);
- .12 short statement<sup>10</sup> describing the principal design elements or changes employed to achieve the attained EEDI (as appropriate), if available;
- .13 type of fuel used in the calculation of the attained EEDI, and for dual-fuel engines, the  $f_{DFgas}$  ratio; and
- .14 ice class designation (if applicable).

3.3 The information in paragraph 3.2 is not required to be reported for ships for which the required and attained EEDI values had been already reported to the Organization.

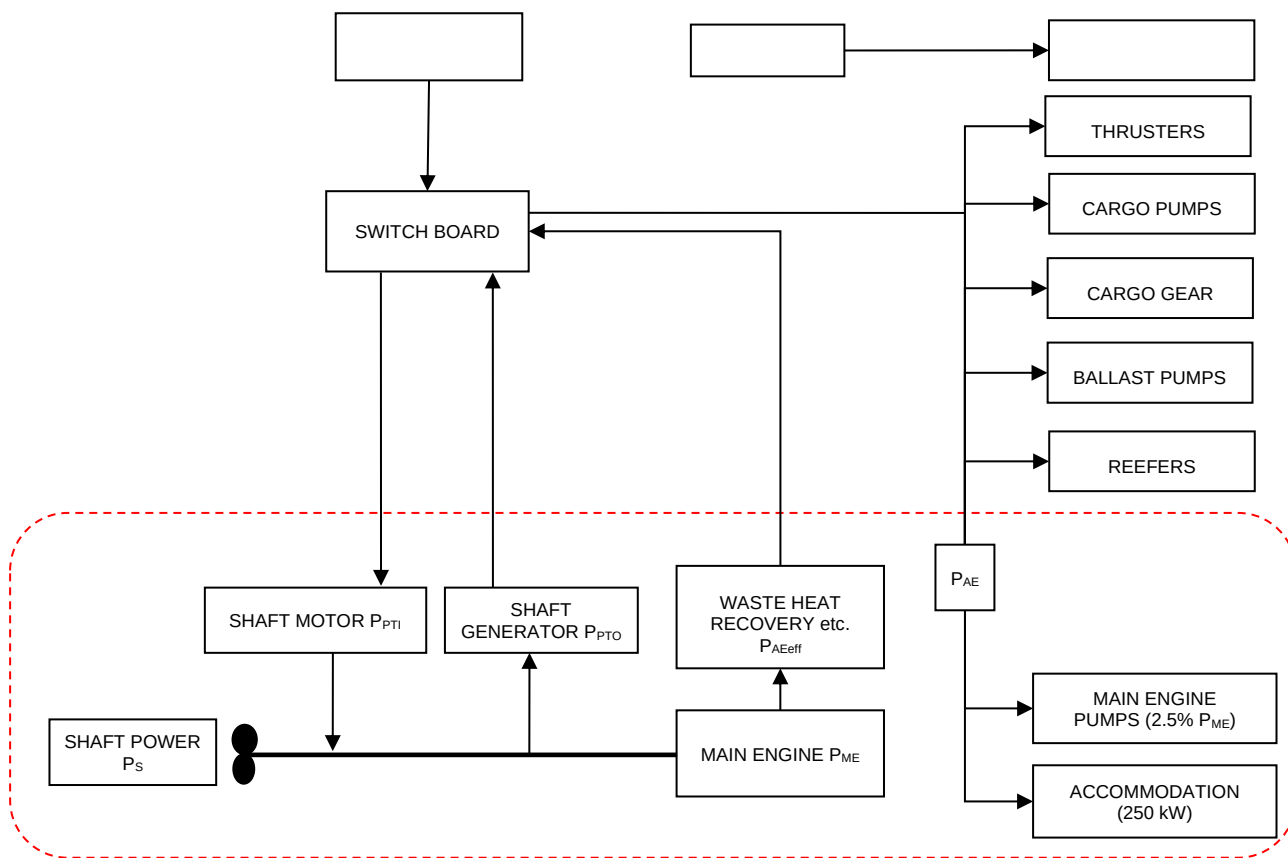
3.4 A standardized reporting format for mandatory reporting of attained EEDI values and related information is presented in appendix 5.

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<sup>10</sup> Not subject to verification.

## APPENDIX 1

### A GENERIC AND SIMPLIFIED MARINE POWER PLANT



**Note 1:** Mechanical recovered waste energy directly coupled to shafts need not be measured, since the effect of the technology is directly reflected in the  $V_{ref}$ .

**Note 2:** In the case of combined PTI/PTO, the normal operational mode at sea will determine which of these to be used in the calculation.

## APPENDIX 2

### GUIDELINES FOR THE DEVELOPMENT OF ELECTRIC POWER TABLES FOR EEDI (EPT-EEDI)

#### 1 Introduction

This appendix contains a guideline for the document "Electric power table for EEDI" which is similar to the actual shipyards' load balance document, utilizing well defined criteria, providing standard format, clear loads definition and grouping, standard load factors, etc. A number of new definitions (in particular the "groups") are introduced, giving an apparent greater complexity to the calculation process. However, this intermediate step to the final calculation of  $P_{AE}$  stimulates all the parties to a deep investigation through the global figure of the auxiliary load, allowing comparisons between different ships and technologies and eventually identifying potential efficiencies improvements.

#### 2 Auxiliary load power definition

$P_{AE}$  is to be calculated as indicated in paragraph 2.2.5.6 of the Guidelines, together with the following additional three conditions:

- .1 non-emergency situations (e.g. "no fire", "no flood", "no blackout", "no partial blackout");
- .2 evaluation time frame of 24 hours (to account loads with intermittent use); and
- .3 ship fully loaded with passengers and/or cargo and crew.

#### 3 Definition of the data to be included in the electric power table for EEDI

The electric power table for EEDI calculation should contain the following data elements, as appropriate:

- .1 Load's group;
- .2 Load's description;
- .3 Load's identification tag;
- .4 Load's electric circuit identification;
- .5 Load's mechanical rated power " $P_m$ " (kW);
- .6 Load's electric motor rated output power (kW);
- .7 Load's electric motor efficiency " $e$ " (/);
- .8 Load's rated electric power " $P_r$ " (kW);
- .9 Service factor of load " $k_l$ " (/);
- .10 Service factor of duty " $k_d$ " (/);
- .11 Service factor of time " $k_t$ " (/);
- .12 Service total factor of use " $k_u$ " (/), where  $k_u = k_l \cdot k_d \cdot k_t$ ;
- .13 Load's necessary power " $P_{load}$ " (kW), where  $P_{load} = P_r \cdot k_u$ ;
- .14 Notes;
- .15 Group's necessary power (kW); and
- .16 Auxiliaries load's power  $P_{AE}$  (kW).

## **4 Data to be included in the electric power table for EEDI**

### ***Load groups***

4.1 The loads are divided into defined groups, allowing a proper breakdown of the auxiliaries. This eases the verification process and makes it possible to identify those areas where load reductions might be possible. The groups are listed below:

- .1 A – Hull, deck, navigation and safety services;
- .2 B – Propulsion service auxiliaries;
- .3 C – Auxiliary engine and main engine services;
- .4 D – Ship's general services;
- .5 E – Ventilation for engine-rooms and auxiliaries room;
- .6 F – Air conditioning services;
- .7 G – Galleys, refrigeration and laundries services;
- .8 H – Accommodation services;
- .9 I – Lighting and socket services;
- .10 L – Entertainment services;
- .11 N – Cargo loads; and
- .12 M – Miscellaneous.

All the ship's loads should be delineated in the document, excluding only  $P_{AEff}$ , the shaft motors and shaft motors chain (while the propulsion services auxiliaries are partially included below in paragraph 4.1.2 B). Some loads (i.e. thrusters, cargo pumps, cargo gear, ballast pumps, maintaining cargo, reefers and cargo hold fans) still are included in the group for sake of transparency; however, their service factor is zero in order to comply with paragraph 2.2.5.6 of the Guidelines (see rows 4 and 5 of the electric power table contained in this appendix), therefore making it easier to verify that all the loads have been considered in the document and there are no loads left out of the measurement.

#### **4.1.1 A – Hull, deck, navigation and safety services**

- .1 loads included in the hull services typically are: ICCP systems, mooring equipment, various doors, ballasting systems, bilge systems, stabilizing equipment, etc. Ballasting systems are indicated with service factor equal to zero to comply with paragraph 2.5.6 of the Guidelines (see row 5 of the electric power table contained in this appendix);
- .2 loads included in the deck services typically are: deck and balcony washing systems, rescue systems, cranes, etc.;
- .3 loads included in the navigation services typically are: navigation systems, navigation's external and internal communication systems, steering systems, etc.; and
- .4 loads included in the safety services typically are: active and passive fire systems, emergency shutdown systems, public address systems, etc.

#### **4.1.2 B – Propulsion service auxiliaries**

This group typically includes propulsion secondary cooling systems, such as LT cooling pumps dedicated to shaft motors, LT cooling pumps dedicated to propulsion converters, propulsion UPSs, etc. Propulsion service loads do not include shaft motors ( $PTI(i)$ ) and the auxiliaries



which are part of them (shaft motor own cooling fans and pump, etc.) and the shaft motor chain losses and auxiliaries which are part of them (i.e. shaft motor converters including relevant auxiliaries such as converter own cooling fans and pumps, shaft motor transformers including relevant auxiliaries losses, such as propulsion transformer own cooling fans and pumps, shaft motor harmonic filter including relevant auxiliaries losses, shaft motor excitation system including the relevant auxiliaries consumed power, etc.). Propulsion service auxiliaries include manoeuvring propulsion equipment such as manoeuvring thrusters and their auxiliaries whose service factor is to be set to zero.

#### 4.1.3 C – Auxiliary engine and main engine services

This group includes cooling systems, i.e. pumps and fans for cooling circuits dedicated to alternators or propulsion shaft engines (seawater, technical water dedicated pumps, etc.), lubricating and fuel systems feeding, transfer, treatment and storage, ventilation system for combustion air supply, etc.

#### 4.1.4 D – Ship's general services

This group includes loads which provide general services which can be shared between shaft motor, auxiliary engines and main engine and accommodation support systems. Loads typically included in this group are cooling systems, i.e. pumping seawater, technical water main circuits, compressed air systems, freshwater generators, automation systems, etc.

#### 4.1.5 E – Ventilation for engine-rooms and auxiliaries room

This group includes all fans providing ventilation for engine-rooms and auxiliary rooms that typically are engine-rooms cooling supply-exhaust fans, auxiliary rooms supply and exhaust fans. All the fans serving accommodation areas or supplying combustion air are not included in this group. This group does not include cargo hold fans and garage supply and exhaust fans.

#### 4.1.6 F – Air conditioning services

All loads that make up the air conditioning service that typically are air conditioning chillers, air conditioning cooling and heating fluids transfer and treatment, air conditioning's air handling units ventilation, air conditioning re-heating systems with associated pumping, etc. The air conditioning chillers service factor of load, service factor of time and service factor of duty are to be set as 1 ( $k_l=1$ ,  $k_t=1$  and  $k_d=1$ ) in order to avoid the detailed validation of the heat load dissipation document (i.e. the chiller's electric motor rated power is to be used). However,  $k_d$  is to represent the use of spare chillers (e.g. four chillers are installed and one out four is spare then  $k_d=0$  for the spare chiller and  $k_d=1$  for the remaining three chillers), but only when the number of spare chillers is clearly demonstrated via the heat load dissipation document.

#### 4.1.7 G – Galleys, refrigeration and laundries services

All loads related to the galleys, pantries refrigeration and laundry services that typically are galleys various machines, cooking appliances, galleys' cleaning machines, galleys auxiliaries, refrigerated room systems including refrigeration compressors with auxiliaries, air coolers, etc.

#### 4.1.8 H – Accommodation services

All loads related to the accommodation services of passengers and crew that typically are crew and passengers' transportation systems, i.e. lifts, escalators, etc. environmental services, i.e. black and grey water collecting, transfer, treatment, storage, discharge, waste systems including collecting, transfer, treatment, storage, etc. accommodation fluids transfers, i.e. sanitary hot and cold water pumping, etc., treatment units, pools systems, saunas, gym equipment, etc.

#### 4.1.9 I – Lighting and socket services

All loads related to the lighting, entertainment and socket services. As the quantity of lighting circuits and sockets within the ship may be significantly high, it is not practically feasible to list all the lighting circuits and points in the EPT for EEDI. Therefore circuits should be grouped into subgroups aimed to identify possible improvements of efficient use of power. The subgroups are:

- .1 Lighting for 1) cabins, 2) corridors, 3) technical rooms/stairs, 4) public spaces/stairs, 5) engine-rooms and auxiliaries' room, 6) external areas, 7) garages and 8) cargo spaces. All should be divided by main vertical zones; and
- .2 Power sockets for 1) cabins, 2) corridors, 3) technical rooms/stairs, 4) public spaces/stairs, 5) engine-rooms and auxiliaries' room, 6) garages and 7) cargo spaces. All should be divided by main vertical zones.

The calculation criteria for complex groups (e.g. cabin lighting and power sockets) subgroups are to be included via an explanatory note, indicating the load composition (e.g. lights of typical cabins, TV, hair dryer, fridge).

#### 4.1.10 L – Entertainment services

This group includes all loads related to entertainment services, typically public spaces audio and video equipment, theatre stage equipment, IT systems for offices, video games, etc.

#### 4.1.11 N – Cargo loads

This group will contain all cargo loads such as cargo pumps, cargo gear, maintaining cargo, cargo reefers loads, cargo hold fans and garage fans for sake of transparency. However, the service factor of this group is to be set to zero.

#### 4.1.12 M – Miscellaneous

This group will contain all loads which have not been associated with the above-mentioned groups but still are contributing to the overall load calculation of the normal maximum sea load.

### ***Loads description***

4.2 This identifies the loads (for example "seawater pump").

### ***Loads identification tag***

4.3 This tag identifies the loads according to the shipyard's standards tagging system. For example, the "PTI1 fresh water pump" identification tag is "SYIYA/C" for an example ship and shipyard. This data provides a unique identifier for each load.

### ***Loads electric circuit identification***

4.4 This is the tag of the electric circuit supplying the load. Such information enables the data validation process.

***Loads mechanical rated power " $P_m$ "***

4.5 This data is to be indicated in the document only when the electric load is made by an electric motor driving a mechanical load (e.g. a fan or a pump). This is the rated power of the mechanical device driven by an electric motor.

***Loads electric motor rated output power (kW)***

4.6 The output power of the electric motor as per maker's name plate or technical specification. This data does not take part of the calculation but is useful to highlight potential over-rating of the combination motor-mechanical load.

***Loads electric motor efficiency " $e$ " (/)***

4.7 This data is to be entered in the document only when the electric load is made by an electric motor driving a mechanical load.

***Loads rated electric power " $P_r$ " (kW)***

4.8 Typically the maximum electric power absorbed at the load electric terminals at which the load has been designed for its service, as indicated on the maker's name plate and/or maker's technical specification. When the electric load is made by an electric motor driving a mechanical load, the load's rated electric power is:  $P_r = P_m / e$  (kW).

***Service factor of load " $kl$ " (/)***

4.9 Provides the reduction from the loads rated electric power to loads necessary electric power that is to be made when the load absorbs less power than its rated power. For example, in the case of an electric motor driving a mechanical load, a fan could be designed with some power margin, leading to the fact that the fan rated mechanical power exceeds the power requested by the duct system it serves. Another example is when a pump rated power exceeds the power needed for pumping in its delivery fluid circuit. Another example is where an electric self-regulating semi-conductors heating system is oversized and the rated power exceeds the power absorbed, according a factor  $kl$ .

***Service factor of duty " $kd$ " (/)***

4.10 Factor of duty is to be used when a function is provided by more than one load. As all loads are to be included in the EPT for EEDI, this factor provides a correct summation of the loads. For example when two pumps serve the same circuit and they run in duty/stand-by their  $kd$  factor will be  $\frac{1}{2}$  and  $\frac{1}{2}$ . When three compressors serve the same circuit and one runs in duty and two in stand-by, then  $kd$  is  $\frac{1}{3}$ ,  $\frac{1}{3}$  and  $\frac{1}{3}$ .

***Service factor of time " $kt$ " (/)***

4.11 A factor of time based on the shipyard's evaluation about the load duty along 24 hours of ship's navigation as defined at paragraph 3. For example the Entertainment loads operate at their power for a limited period of time, 4 hours out 24 hours; as a consequence  $kt = 4/24$ . For example, the seawater cooling pumps operate at their power all the time during the navigation at  $V_{ref}$ . As a consequence  $kt = 1$ .

**Service total factor of use "ku" (I)**

4.12 The total factor of use that takes into consideration all the service factors:  $ku=kl \cdot kd \cdot kt$ .

**Loads necessary power "Pload" (kW)**

4.13 The individual user contribution to the auxiliary load power is  $Pload=Pr \cdot ku$ .

**Notes**

4.14 A note, as free text, could be included in the document to provide explanations to the verifier.

**Groups necessary power (kW)**

4.15 The summation of the "Loads necessary power" from group A to N. This is an intermediate step which is not strictly necessary for the calculation of *PAE*. However, it is useful to allow a quantitative analysis of the *PAE*, providing a standard breakdown for analysis and potential improvements of energy saving.

**Auxiliaries load's power PAE (kW)**

4.16 Auxiliaries load's power *PAE* is the summation of the "Load's necessary power" of all the loads divided by the average efficiency of the generator(s) weighted by power.

$$PAE = \sum Pload(i) / (\text{average efficiency of the generator(s) weighted by power})$$

**Layout and organization of the data indicated in the electric power table for EEDI**

5 The document "Electric power table for EEDI" is to include general information (i.e. ship's name, project name, document references, etc.) and a table with:

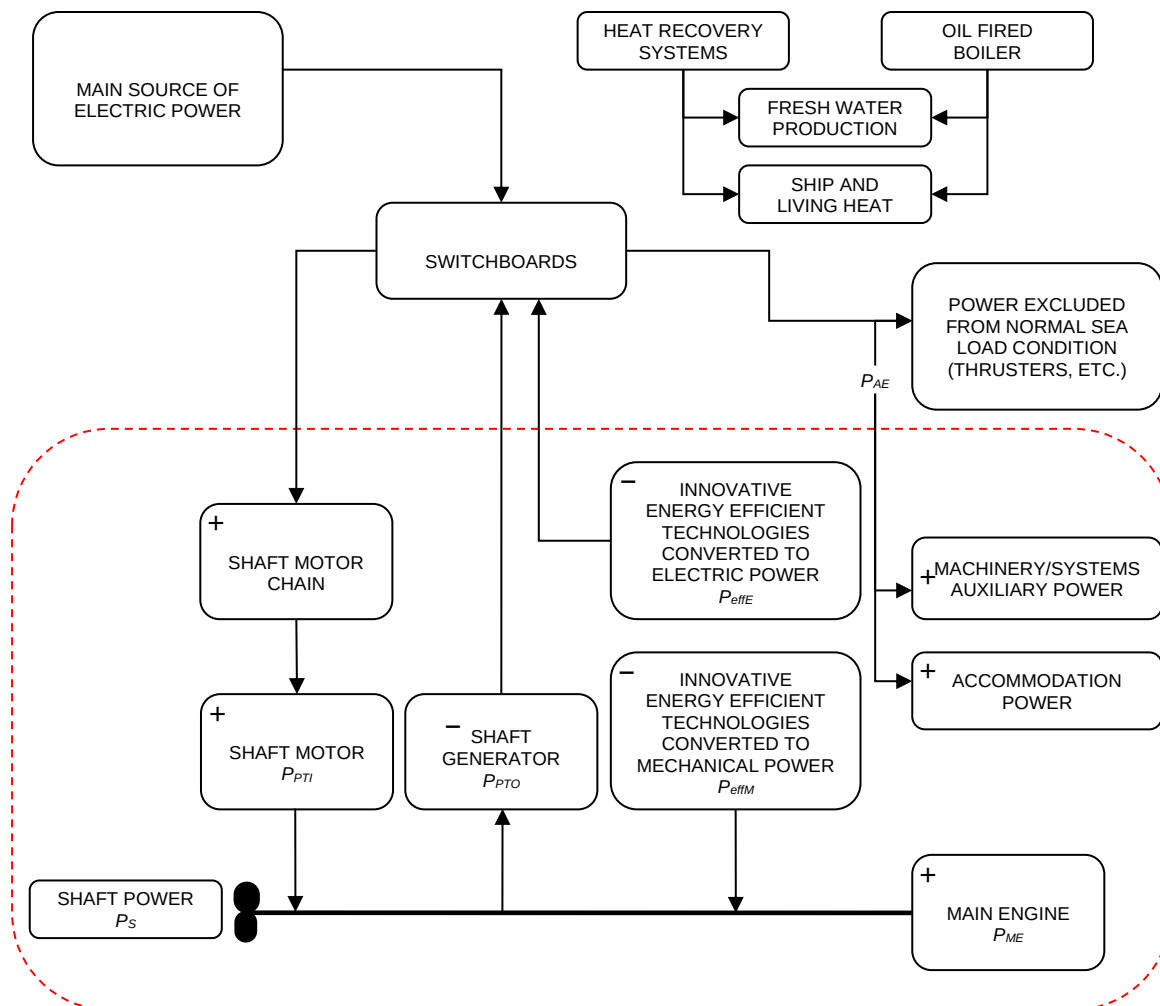
- .1 one row containing column titles;
- .2 one column for table row ID;
- .3 one column for the groups identification ("A", "B", etc.) as indicated in paragraphs 4.1.1 to 4.1.12 of this appendix;
- .4 one column for the group descriptions as indicated in paragraphs 4.1.1 to 4.1.12 of this appendix;
- .5 one column each for items in paragraphs 4.2 to 4.14 of this appendix (e.g. "load tag");
- .6 one row dedicated to each individual load;
- .7 the summation results (i.e. summation of powers) including data from paragraphs 4.15 to 4.16 of this appendix; and
- .8 explanatory notes.

An example of an electric power table for EEDI for a cruise postal ship which transports passengers and has a car garage and reefer holds for fish trade transportation is indicated below. The data indicated and the type of ship are for reference only.

| ELECTRIC POWER TABLE FOR EEDI                                                                                                                  |            |                                               | HULL "EXAMPLE"          |                                      | PROJECT "EXAMPLE"                     |                                             |                                        |                                     |                                 |                                 |                                 |                                      |                                   |                                                     | (NMSL=Normal Maximum Sea Load) |  |
|------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----------------------------------------------|-------------------------|--------------------------------------|---------------------------------------|---------------------------------------------|----------------------------------------|-------------------------------------|---------------------------------|---------------------------------|---------------------------------|--------------------------------------|-----------------------------------|-----------------------------------------------------|--------------------------------|--|
| id                                                                                                                                             | Load group | Load description                              | Load identification tag | Load electric circuit identification | Load mechanical rated power "Pm" [kW] | Load electric motor rated output power [kW] | Load electric motor efficiency "e" [%] | Load Rated electric power "Pr" [kW] | service factor of load "kl" [%] | service factor of duty "kd" [%] | service factor of time "kt" [%] | service total factor of use "ku" [%] | Load necessary power "Pload" [kW] | Note                                                |                                |  |
| 1                                                                                                                                              | A          | Hull cathodic protection Fwd                  | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 5.2                                 | 1                               | 1                               | 1*                              | 1                                    | 5.2                               | *in use 24hours/day                                 |                                |  |
| 2                                                                                                                                              | A          | Hull cathodic protection mid                  | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 7.0                                 | 1                               | 1                               | 1*                              | 1                                    | 7                                 | *in use 24hours/day                                 |                                |  |
| 3                                                                                                                                              | A          | Hull cathodic protection aft                  | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 4.8                                 | 1                               | 1                               | 1*                              | 1                                    | 4.8                               | *in use 24hours/day                                 |                                |  |
| 4                                                                                                                                              | A          | Ballast pump 3                                | xxx                     | yyy                                  | 30                                    | 36                                          | 0.92                                   | 32.6                                | 0.9                             | 0.5                             | 1                               | 0*                                   | 0                                 | *not in use at NMSL see para 2.5.6 of Circ.681      |                                |  |
| 5                                                                                                                                              | A          | Fwd Stb mooring winch motor n.1               | xxx                     | yyy                                  | 90                                    | 150                                         | 0.92                                   | 97.8                                | 0.8                             | 1                               | 0*                              | 0*                                   | 0                                 | *not in use at NMSL see para 2.5.6 of Circ.681      |                                |  |
| 6                                                                                                                                              | A          | WTDs system main control panel                | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 0.5                                 | 1                               | 1                               | 1*                              | 1                                    | 0.5                               | *in use 24hours/day                                 |                                |  |
| 7                                                                                                                                              | A          | WTD 1, deck D frame 150                       | xxx                     | yyy                                  | 1.2                                   | 3                                           | 0.91                                   | 1.3                                 | 0.7                             | 1                               | 0.104*                          | 0.0728                               | 0.096                             | *180 secs to open/close x 100 opening a day         |                                |  |
| 8                                                                                                                                              | A          | WTD 5, deck D frame 210                       | xxx                     | yyy                                  | 1.2                                   | 3                                           | 0.91                                   | 1.3                                 | 0.7                             | 1                               | 0.156*                          | 0.1092                               | 0.14                              | *180 secs to open/close x 150 opening a day         |                                |  |
| 9                                                                                                                                              | A          | Stabilisers control unit                      | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 0.7                                 | 1                               | 1                               | 1*                              | 1                                    | 0.7                               | *in use 24hours/day                                 |                                |  |
| 10                                                                                                                                             | A          | Stabilisers Hydraulic pack power pump 1       | xxx                     | yyy                                  | 80                                    | 90                                          | 0.9                                    | 88.9                                | 0.9                             | 1                               | 0*                              | 0                                    | 0                                 | *NMSL=> calm sea,=> stabiliser not in use           |                                |  |
| 11                                                                                                                                             | A          | S-band Radar 1 controller                     | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 0.4                                 | 1                               | 1                               | 1*                              | 1                                    | 0.4                               | *in use 24hours/day                                 |                                |  |
| 12                                                                                                                                             | A          | S-band Radar 1 motor                          | xxx                     | yyy                                  | 0.8                                   | 1                                           | 0.92                                   | 0.9                                 | 1                               | 1                               | 1*                              | 1                                    | 0.9                               | *in use 24hours/day                                 |                                |  |
| 13                                                                                                                                             | A          | Fire detection system bridge main unit        | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 1.5                                 | 1                               | 1                               | 1*                              | 1                                    | 1.5                               | *in use 24hours/day                                 |                                |  |
| 14                                                                                                                                             | A          | Fire detection system ECR unit                | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 0.9                                 | 1                               | 1                               | 1*                              | 1                                    | 0.9                               | *in use 24hours/day                                 |                                |  |
| 15                                                                                                                                             | A          | High pressure water fog control unit          | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 1.2                                 | 1                               | 1                               | 1*                              | 1                                    | 1.2                               | *in use 24hours/day                                 |                                |  |
| 16                                                                                                                                             | A          | High pressure water fog engines rooms pump 1a | xxx                     | yyy                                  | 25                                    | 30                                          | 0.93                                   | 26.9                                | 0.9                             | 0.5                             | 0*                              | 0                                    | 0                                 | *NMSL=> not emergency =>Load not in use             |                                |  |
| 17                                                                                                                                             | A          | High pressure water fog engines rooms pump 1b | xxx                     | yyy                                  | 25                                    | 30                                          | 0.93                                   | 26.9                                | 0.9                             | 0.5                             | 0*                              | 0                                    | 0                                 | * not emergency situations                          |                                |  |
| 18                                                                                                                                             | B          | PTI port fresh water pump 1                   | xxx                     | yyy                                  | 30                                    | 36                                          | 0.92                                   | 32.6                                | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 14.7                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 19                                                                                                                                             | B          | PTI port fresh water pump 2                   | xxx                     | yyy                                  | 30                                    | 36                                          | 0.92                                   | 32.6                                | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 14.7                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 20                                                                                                                                             | B          | Thrusters control system                      | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 0.5                                 | 1                               | 1                               | 1*                              | 1                                    | 0.5                               | in use 24hours/day (even if thruster motor isn't)   |                                |  |
| 21                                                                                                                                             | B          | Bow thruster 1                                | xxx                     | yyy                                  | 3000                                  | 3000                                        | 0.96                                   | 3125.0                              | 1                               | 1                               | 0*                              | 0                                    | 0                                 | *NMSL=>thrusters motor are not in use               |                                |  |
| 22                                                                                                                                             | B          | PEM port cooling fan 1                        | xxx                     | yyy                                  | 20                                    | 25                                          | 0.93                                   | 21.5                                | 0.9                             | 1                               | n.a.                            | n.a                                  | n.a.*                             | *this load is included in the propulsion chain data |                                |  |
| 23                                                                                                                                             | C          | HT circulation pump 1 DG 3                    | xxx                     | yyy                                  | 8                                     | 10                                          | 0.92                                   | 8.7                                 | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 3.9                               | * pump1,2 one is duty and one is stand-by           |                                |  |
| 24                                                                                                                                             | C          | HT circulation pump 2 DG 3                    | xxx                     | yyy                                  | 8                                     | 10                                          | 0.92                                   | 8.7                                 | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 3.9                               | * pump1,2 one is duty and one is stand-by           |                                |  |
| 25                                                                                                                                             | C          | DG3 combustion air fan                        | xxx                     | yyy                                  | 28                                    | 35                                          | 0.92                                   | 30.4                                | 0.9                             | 1                               | 1*                              | 0.9                                  | 27.4                              | *in use 24hours/day                                 |                                |  |
| 26                                                                                                                                             | C          | DG3 exhaust gas boiler circulating pump       | xxx                     | yyy                                  | 6                                     | 8                                           | 0.93                                   | 6.5                                 | 0.8                             | 1                               | 1*                              | 0.8                                  | 5.2                               | *in use 24hours/day                                 |                                |  |
| 27                                                                                                                                             | C          | Alternator 3 external cooling fan             | xxx                     | yyy                                  | 3                                     | 5                                           | 0.93                                   | 3.2                                 | 0.8                             | 1                               | 1*                              | 0.8                                  | 2.75                              | *in use 24hours/day                                 |                                |  |
| 28                                                                                                                                             | C          | fuel feed fwd booster pump a                  | xxx                     | yyy                                  | 7                                     | 9                                           | 0.92                                   | 7.6                                 | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 3.4                               | * pump1,2 one is duty and one is stand-by           |                                |  |
| 29                                                                                                                                             | C          | fuel feed fwd booster pump b                  | xxx                     | yyy                                  | 7                                     | 9                                           | 0.92                                   | 7.6                                 | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 3.4                               | * pump1,2 one is duty and one is stand-by           |                                |  |
| 30                                                                                                                                             | D          | Fwd main LT cooling pump 1                    | xxx                     | yyy                                  | 120                                   | 150                                         | 0.95                                   | 126.3                               | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 56.8                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 31                                                                                                                                             | D          | Fwd main LT cooling pump 2                    | xxx                     | yyy                                  | 120                                   | 150                                         | 0.95                                   | 126.3                               | 0.9                             | 0.5*                            | 1                               | 0.45                                 | 56.8                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 32                                                                                                                                             | E          | FWD engine room supply fan 1                  | xxx                     | yyy                                  | 87.8                                  | 110                                         | 0.93                                   | 94.4                                | 0.95                            | 1                               | 1*                              | 0.95                                 | 89.7                              | *in use 24hours/day                                 |                                |  |
| 33                                                                                                                                             | E          | FWD engine room exhaust fan 1                 | xxx                     | yyy                                  | 75                                    | 86                                          | 0.93                                   | 80.6                                | 0.96                            | 1                               | 1*                              | 0.96                                 | 77.4                              | *in use 24hours/day                                 |                                |  |
| 34                                                                                                                                             | E          | purifier room supply fan 1                    | xxx                     | yyy                                  | 60                                    | 70                                          | 0.93                                   | 64.5                                | 0.96                            | 0.5                             | 1*                              | 0.48                                 | 31.0                              | *in use 24hours/day                                 |                                |  |
| 35                                                                                                                                             | E          | purifier room supply fan 2                    | xxx                     | yyy                                  | 60                                    | 70                                          | 0.93                                   | 64.5                                | 0.96                            | 0.5                             | 1*                              | 0.48                                 | 31.0                              | *in use 24hours/day                                 |                                |  |
| 36                                                                                                                                             | F          | HVAC chiller a                                | xxx                     | yyy                                  | 1450                                  | 1600                                        | 0.95                                   | 1526.3                              | 1                               | 2/3*                            | 1                               | 0.66                                 | 1007.4                            | *1 Chiller is spare; see heat load dissipation doc. |                                |  |
| 37                                                                                                                                             | F          | HVAC chiller b                                | xxx                     | yyy                                  | 1450                                  | 1600                                        | 0.95                                   | 1526.3                              | 1                               | 2/3*                            | 1                               | 0.66                                 | 1007.4                            | *1 Chiller is spare; see heat load dissipation doc. |                                |  |
| 38                                                                                                                                             | F          | HVAC chiller C                                | xxx                     | yyy                                  | 1450                                  | 1600                                        | 0.95                                   | 1526.3                              | 1                               | 2/3*                            | 1                               | 0.66                                 | 1007.4                            | *1 Chiller is spare; see heat load dissipation doc. |                                |  |
| 39                                                                                                                                             | F          | A.H.U. Ac station 5.4 supply fan              | xxx                     | yyy                                  | 50                                    | 60                                          | 0.93                                   | 53.8                                | 0.9                             | 1                               | 1*                              | 0.9                                  | 48.4                              | *in use 24hours/day                                 |                                |  |
| 40                                                                                                                                             | F          | A.H.U. Ac station 5.4 exhaust fan             | xxx                     | yyy                                  | 45                                    | 55                                          | 0.93                                   | 48.4                                | 0.9                             | 1                               | 1*                              | 0.9                                  | 43.5                              | *in use 24hours/day                                 |                                |  |
| 41                                                                                                                                             | F          | Chilled water pump a                          | xxx                     | yyy                                  | 80                                    | 90                                          | 0.93                                   | 86.0                                | 0.88                            | 0.5*                            | 1                               | 0.44                                 | 37.8                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 42                                                                                                                                             | F          | Chilled water pump b                          | xxx                     | yyy                                  | 80                                    | 90                                          | 0.93                                   | 86.0                                | 0.88                            | 0.5*                            | 1                               | 0.44                                 | 37.8                              | * pump1,2 one is duty and one is stand-by           |                                |  |
| 43                                                                                                                                             | G          | Italian's espresso coffee machine             | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 7.0                                 | 0.9                             | 1                               | 0.2*                            | 0.18                                 | 1.3                               | *in use 4.8hours/day                                |                                |  |
| 44                                                                                                                                             | G          | deep freezer machine                          | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 20.0                                | 0.8                             | 1                               | 0.16*                           | 0.128                                | 3.2                               | *in use 4hours/day                                  |                                |  |
| 45                                                                                                                                             | G          | washing machine 1                             | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 8.0                                 | 0.8                             | 1                               | 0.33*                           | 0.264                                | 3.2                               | *in use 8hours/day                                  |                                |  |
| 46                                                                                                                                             | H          | lift pax mid 4                                | xxx                     | yyy                                  | 30                                    | 40                                          | 0.93                                   | 32.3                                | 0.5                             | 1                               | 0.175*                          | 0.0875                               | 0.9                               | *in use 4hours/day                                  |                                |  |
| 47                                                                                                                                             | H          | vacuum collecting system 4 pump a             | xxx                     | yyy                                  | 10                                    | 13                                          | 0.92                                   | 10.9                                | 0.9                             | 1                               | 1*                              | 0.9                                  | 8.7                               | *in use 24hours/day                                 |                                |  |
| 48                                                                                                                                             | H          | sewage treatmet system 1 pump 1               | xxx                     | yyy                                  | 15                                    | 17                                          | 0.93                                   | 16.1                                | 0.9                             | 1                               | 1*                              | 0.9                                  | 8.7                               | *in use 24hours/day                                 |                                |  |
| 49                                                                                                                                             | H          | Gym running machine                           | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 2.5                                 | 1                               | 1                               | 0.3*                            | 0.3                                  | 0.8                               | *in use 7.2hours/day                                |                                |  |
| 50                                                                                                                                             | I          | Cabin's lighting MV23                         | n.a.                    | n.a.                                 | n.a.                                  | n.a.                                        | n.a.                                   | 80*                                 | 1                               | 1                               | 1                               | 1                                    | 80.0                              | * see explanatory note                              |                                |  |
| 51                                                                                                                                             | I          | corridors lighting MV23                       | n.a.                    | n.a.                                 | n.a.                                  | n.a.                                        | n.a.                                   | 10*                                 | 1                               | 1                               | 1                               | 1                                    | 10.0                              | * see explanatory note                              |                                |  |
| 52                                                                                                                                             | I          | Cabin's sockets MV23                          | n.a.                    | n.a.                                 | n.a.                                  | n.a.                                        | n.a.                                   | 5*                                  | 1                               | 1                               | 1                               | 1                                    | 5.0                               | * see explanatory note                              |                                |  |
| 53                                                                                                                                             | L          | Main Theatre audio booster amplifier          | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 15.0                                | 1                               | 1                               | 0.3*                            | 0.3                                  | 4.5                               | *in use 7.2hours/day                                |                                |  |
| 54                                                                                                                                             | L          | Video wall atrium                             | xxx                     | yyy                                  | n.a.                                  | n.a.                                        | n.a.                                   | 2.0                                 | 1                               | 1                               | 0.3*                            | 0.3                                  | 0.6                               | *in use 7.2hours/day                                |                                |  |
| 55                                                                                                                                             | M          | Car Garage supply fan1                        | xxx                     | yyy                                  | 28                                    | 35                                          | 0.92                                   | 30.4                                | 0.9                             | 1                               | 1*                              | 0*                                   | 0                                 | *not in use at NMSL see para 2.5.6 of Circ.681      |                                |  |
| 56                                                                                                                                             | M          | Fish transportation reefer hold n.2           | xxx                     | yyy                                  | 25                                    | 30                                          | 0.93                                   | 26.9                                | 0.9                             | 0.5                             | 0*                              | 0*                                   | 0                                 | *not in use at NMSL see para 2.5.6 of Circ.681      |                                |  |
| 57                                                                                                                                             | N          | Sliding glass roof                            | xxx                     | yyy                                  | 30                                    | 40                                          | 0.93                                   | 32.3                                | 0.9                             | 1                               | 0.3*                            | 0.27                                 | 0.2                               | *in use 7.2hours/day                                |                                |  |
| ΣPload(i)=                                                                                                                                     |            |                                               |                         |                                      |                                       |                                             |                                        |                                     |                                 |                                 |                                 |                                      | 3764                              |                                                     |                                |  |
| PAE =3764/(weighted average efficiency of generator(s)) [kW]                                                                                   |            |                                               |                         |                                      |                                       |                                             |                                        |                                     |                                 |                                 |                                 |                                      |                                   |                                                     |                                |  |
| Group's necessary power (group A=22.9kW, B=29.8kW, C=49.9kW, D=113.7kW, E=229kW , F=3189kW, G=7.6kW, H=19kW, I=95kW, L=5.1kW, M=0kW, N=0.22kW) |            |                                               |                         |                                      |                                       |                                             |                                        |                                     |                                 |                                 |                                 |                                      |                                   |                                                     |                                |  |

### APPENDIX 3

#### A GENERIC AND SIMPLIFIED MARINE POWER PLANT FOR A CRUISE PASSENGER SHIPS HAVING NON-CONVENTIONAL PROPULSION

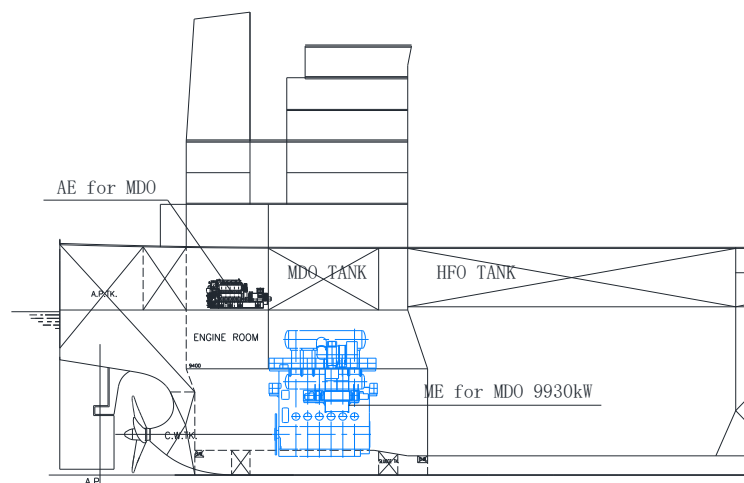


**Note:** Symbols for plus (+) and minus (–) indicate CO<sub>2</sub> contribution to EEDI formula.

## APPENDIX 4

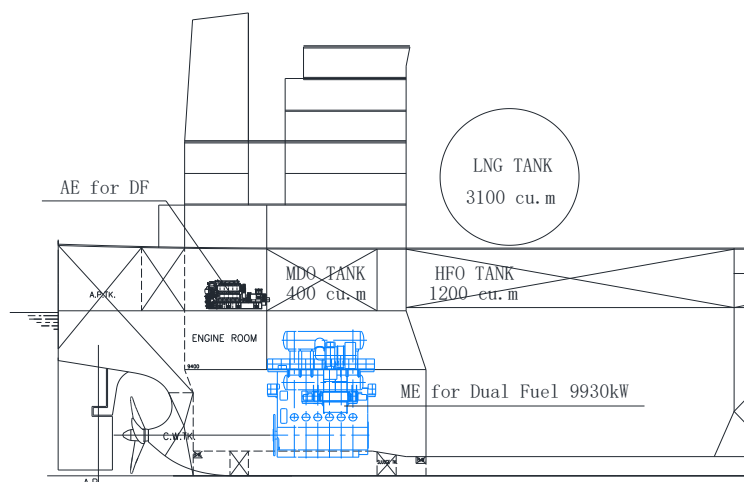
### EEDI CALCULATION EXAMPLES FOR USE OF DUAL-FUEL ENGINES

Case 1: Standard Kamsarmax ship, one main engine (MDO), standard auxiliary engines (MDO), no shaft generator:



| S/N | Parameter  | Formula or Source                                                                                                       | Unit                  | Value   |
|-----|------------|-------------------------------------------------------------------------------------------------------------------------|-----------------------|---------|
| 1   | $MCR_{ME}$ | MCR rating of main engine                                                                                               | kW                    | 9,930   |
| 2   | Capacity   | Deadweight of the ship at summer load draft                                                                             | DWT                   | 81,200  |
| 3   | $V_{ref}$  | Ships speed as defined in EEDI regulation                                                                               | kn                    | 14      |
| 4   | $P_{ME}$   | $0.75 \times MCR_{ME}$                                                                                                  | kW                    | 7,447.5 |
| 5   | $P_{AE}$   | $0.05 \times MCR_{ME}$                                                                                                  | kW                    | 496.5   |
| 6   | $C_{FME}$  | $C_F$ factor of Main engine using MDO                                                                                   | -                     | 3.206   |
| 7   | $C_{FAE}$  | $C_F$ factor of Auxiliary engine using MDO                                                                              | -                     | 3.206   |
| 8   | $SFC_{ME}$ | Specific fuel consumption of at $P_{ME}$                                                                                | g/kWh                 | 165     |
| 9   | $SFC_{AE}$ | Specific fuel consumption of at $P_{AE}$                                                                                | g/kWh                 | 210     |
| 10  | EEDI       | $\frac{((P_{ME} \times C_{FME} \times SFC_{ME}) + (P_{AE} \times C_{FAE} \times SFC_{AE}))}{(V_{ref} \times Capacity)}$ | gCO <sub>2</sub> /tnm | 3.76    |

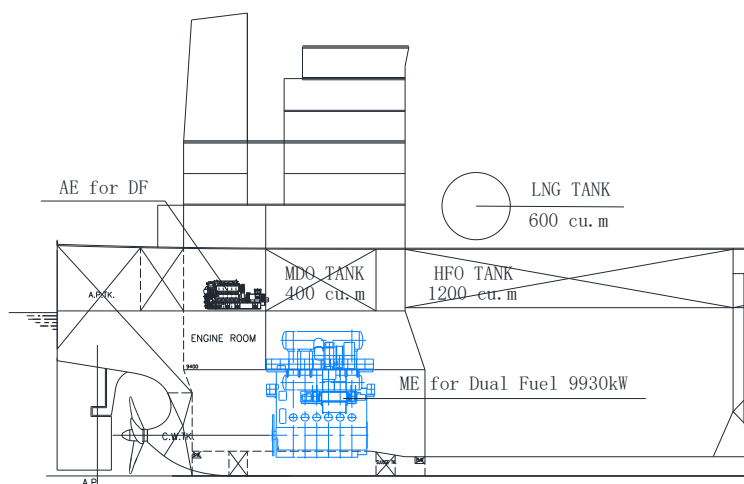
Case 2: LNG is regarded as the "primary fuel" if dual-fuel main engine and dual-fuel auxiliary engine (LNG, pilot fuel MDO; no shaft generator) are equipped with bigger LNG tanks:



| S/N | Parameter                   | Formula or Source                                                                                                                                                                                                                                                                                    | Unit                  | Value   |
|-----|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------|
| 1   | MCR <sub>ME</sub>           | MCR rating of main engine                                                                                                                                                                                                                                                                            | kW                    | 9,930   |
| 2   | Capacity                    | Deadweight of the ship at summer load draft                                                                                                                                                                                                                                                          | DWT                   | 81,200  |
| 3   | V <sub>ref</sub>            | Ships speed as defined in EEDI regulation                                                                                                                                                                                                                                                            | kn                    | 14      |
| 4   | P <sub>ME</sub>             | 0.75 x MCR <sub>ME</sub>                                                                                                                                                                                                                                                                             | kW                    | 7,447.5 |
| 5   | P <sub>AE</sub>             | 0.05 x MCR <sub>ME</sub>                                                                                                                                                                                                                                                                             | kW                    | 496.5   |
| 6   | CF <sub>Pilotfuel</sub>     | C <sub>F</sub> factor of pilot fuel for dual-fuel ME using MDO                                                                                                                                                                                                                                       | -                     | 3.206   |
| 7   | CF <sub>AE Pilotfuel</sub>  | C <sub>F</sub> factor of pilot fuel for Auxiliary engine using MDO                                                                                                                                                                                                                                   | -                     | 3.206   |
| 8   | CF <sub>LNG</sub>           | C <sub>F</sub> factor of dual-fuel engine using LNG                                                                                                                                                                                                                                                  | -                     | 2.75    |
| 9   | SFC <sub>ME Pilotfuel</sub> | Specific fuel consumption of pilot fuel for dual-fuel ME at P <sub>ME</sub>                                                                                                                                                                                                                          | g/kWh                 | 6       |
| 10  | SFC <sub>AE Pilotfuel</sub> | Specific fuel consumption of pilot fuel for dual-fuel AE at P <sub>AE</sub>                                                                                                                                                                                                                          | g/kWh                 | 7       |
| 11  | SFC <sub>ME LNG</sub>       | Specific fuel consumption of ME using LNG at P <sub>ME</sub>                                                                                                                                                                                                                                         | g/kWh                 | 136     |
| 12  | SFC <sub>AE LNG</sub>       | Specific fuel consumption of AE using LNG at P <sub>AE</sub>                                                                                                                                                                                                                                         | g/kWh                 | 160     |
| 13  | V <sub>LNG</sub>            | LNG tank capacity on board                                                                                                                                                                                                                                                                           | m <sup>3</sup>        | 3,100   |
| 14  | V <sub>HFO</sub>            | Heavy fuel oil tank capacity on board                                                                                                                                                                                                                                                                | m <sup>3</sup>        | 1,200   |
| 15  | V <sub>MDO</sub>            | Marine diesel oil tank capacity on board                                                                                                                                                                                                                                                             | m <sup>3</sup>        | 400     |
| 16  | ρ <sub>LNG</sub>            | Density of LNG                                                                                                                                                                                                                                                                                       | kg/m <sup>3</sup>     | 450     |
| 17  | ρ <sub>HFO</sub>            | Density of heavy fuel oil                                                                                                                                                                                                                                                                            | kg/m <sup>3</sup>     | 991     |
| 18  | ρ <sub>MDO</sub>            | Density of marine diesel oil                                                                                                                                                                                                                                                                         | kg/m <sup>3</sup>     | 900     |
| 19  | LCV <sub>LNG</sub>          | Low calorific value of LNG                                                                                                                                                                                                                                                                           | kJ/kg                 | 48,000  |
| 20  | LCV <sub>HFO</sub>          | Low calorific value of heavy fuel oil                                                                                                                                                                                                                                                                | kJ/kg                 | 40,200  |
| 21  | LCV <sub>MDO</sub>          | Low calorific value of marine diesel oil                                                                                                                                                                                                                                                             | kJ/kg                 | 42,700  |
| 22  | K <sub>LNG</sub>            | Filling rate of LNG tank                                                                                                                                                                                                                                                                             | -                     | 0.95    |
| 23  | K <sub>HFO</sub>            | Filling rate of heavy fuel tank                                                                                                                                                                                                                                                                      | -                     | 0.98    |
| 24  | K <sub>MDO</sub>            | Filling rate of marine diesel tank                                                                                                                                                                                                                                                                   | -                     | 0.98    |
| 25  | f <sub>DFgas</sub>          | $\frac{P_{ME} + P_{AE}}{P_{ME} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$ | -                     | 0.5068  |
| 26  | EEDI                        | $\frac{(P_{ME} \times (C_F \text{ Pilotfuel} \times SFC_{ME \text{ Pilotfuel}} + C_F \text{ LNG} \times SFC_{ME \text{ LNG}}) + P_{AE} \times (C_F \text{ Pilotfuel} \times SFC_{AE \text{ Pilotfuel}} + C_F \text{ LNG} \times SFC_{AE \text{ LNG}}))}{(V_{ref} \times Capacity)}$                  | gCO <sub>2</sub> /tnm | 2.78    |



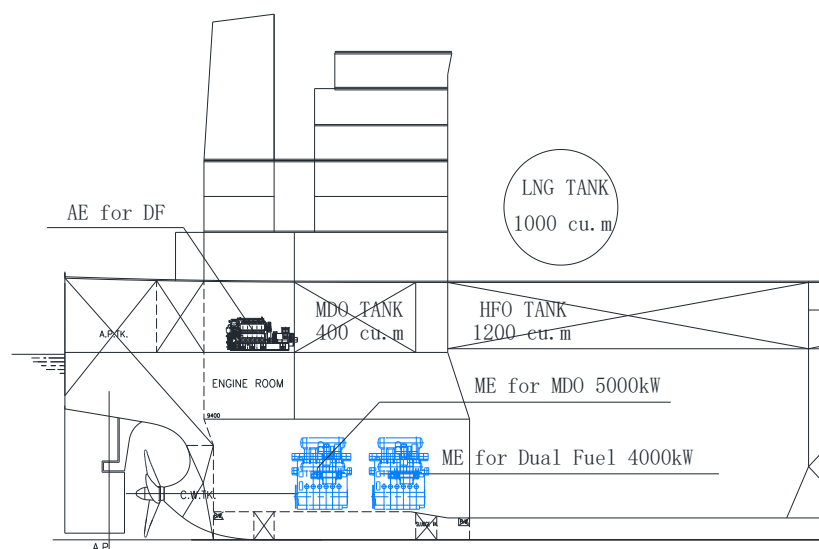
Case 3: LNG is not regarded as the "primary fuel" if dual-fuel main engine and dual-fuel auxiliary engine (LNG, pilot fuel MDO; no shaft generator) are equipped with smaller LNG tanks:



| S/N | Parameter            | Formula or Source                                                    | Unit              | Value   |
|-----|----------------------|----------------------------------------------------------------------|-------------------|---------|
| 1   | $MCR_{ME}$           | MCR rating of main engine                                            | kW                | 9,930   |
| 2   | Capacity             | Deadweight of the ship at summer load draft                          | DWT               | 81,200  |
| 3   | $V_{ref}$            | Ships speed as defined in EEDI regulation                            | kn                | 14      |
| 4   | $P_{ME}$             | $0.75 \times MCR_{ME}$                                               | kW                | 7,447.5 |
| 5   | $P_{AE}$             | $0.05 \times MCR_{ME}$                                               | kW                | 496.5   |
| 6   | $C_{FPilotfuel}$     | $C_F$ factor of pilot fuel for dual-fuel ME using MDO                | -                 | 3.206   |
| 7   | $C_{FAE Pilotfuel}$  | $C_F$ factor of pilot fuel for Auxiliary engine using MDO            | -                 | 3.206   |
| 8   | $C_{FLNG}$           | $C_F$ factor of dual-fuel engine using LNG                           | -                 | 2.75    |
| 9   | $C_{FMDO}$           | $C_F$ factor of dual-fuel ME/AE engine using MDO                     | -                 | 3.206   |
| 10  | $SFC_{MEPilotfuel}$  | Specific fuel consumption of pilot fuel for dual-fuel ME at $P_{ME}$ | g/kWh             | 6       |
| 11  | $SFC_{AE Pilotfuel}$ | Specific fuel consumption of pilot fuel for dual-fuel AE at $P_{AE}$ | g/kWh             | 7       |
| 12  | $SFC_{ME LNG}$       | Specific fuel consumption of ME using LNG at $P_{ME}$                | g/kWh             | 136     |
| 13  | $SFC_{AE LNG}$       | Specific fuel consumption of AE using LNG at $P_{AE}$                | g/kWh             | 160     |
| 14  | $SFC_{ME MDO}$       | Specific fuel consumption of dual-fuel ME using MDO at $P_{ME}$      | g/kWh             | 165     |
| 15  | $SFC_{AE MDO}$       | Specific fuel consumption of dual-fuel AE using MDO at $P_{AE}$      | g/kWh             | 187     |
| 16  | $V_{LNG}$            | LNG tank capacity on board                                           | m <sup>3</sup>    | 600     |
| 17  | $V_{HFO}$            | Heavy fuel oil tank capacity on board                                | m <sup>3</sup>    | 1,800   |
| 18  | $V_{MDO}$            | Marine diesel oil tank capacity on board                             | m <sup>3</sup>    | 400     |
| 19  | $\rho_{LNG}$         | Density of LNG                                                       | kg/m <sup>3</sup> | 450     |
| 20  | $\rho_{HFO}$         | Density of heavy fuel oil                                            | kg/m <sup>3</sup> | 991     |
| 21  | $\rho_{MDO}$         | Density of marine diesel oil                                         | kg/m <sup>3</sup> | 900     |
| 22  | $LCV_{LNG}$          | Low calorific value of LNG                                           | kJ/kg             | 48,000  |
| 24  | $LCV_{HFO}$          | Low calorific value of heavy fuel oil                                | kJ/kg             | 40,200  |
| 25  | $LCV_{MDO}$          | Low calorific value of marine diesel oil                             | kJ/kg             | 42,700  |
| 26  | $K_{LNG}$            | Filling rate of LNG tank                                             | -                 | 0.95    |
| 27  | $K_{HFO}$            | Filling rate of heavy fuel tank                                      | -                 | 0.98    |
| 28  | $K_{MDO}$            | Filling rate of marine diesel tank                                   | -                 | 0.98    |

| S/N | Parameter      | Formula or Source                                                                                                                                                                                                                                                                                                                                                                 | Unit                  | Value  |
|-----|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------|
| 29  | $f_{DFgas}$    | $\frac{P_{ME} + P_{AE}}{P_{ME} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$                                                                              | -                     | 0.1261 |
| 30  | $f_{DFliquid}$ | $1 - f_{DFgas}$                                                                                                                                                                                                                                                                                                                                                                   | -                     | 0.8739 |
| 31  | EEDI           | $(P_{ME} \times (f_{DFgas} \times (C_F^{Pilotfuel} \times SFC_{ME}^{Pilotfuel} + C_F^{LNG} \times SFC_{ME}^{LNG}) + f_{DFliquid} \times C_{FMDO} \times SFC_{ME}^{MDO}) + P_{AE} \times (f_{DFgas} \times (C_{FAE}^{Pilotfuel} \times SFC_{AE}^{Pilotfuel} + C_F^{LNG} \times SFC_{AE}^{LNG}) + f_{DFliquid} \times C_{FMDO} \times SFC_{AE}^{MDO})) / (V_{ref} \times Capacity)$ | gCO <sub>2</sub> /tnm | 3.61   |

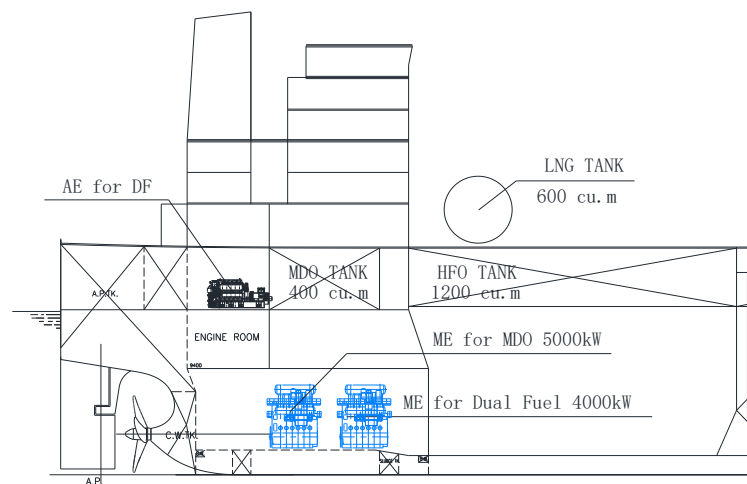
Case 4: One dual-fuel main engine (LNG, pilot fuel MDO) and one main engine (MDO) and dual-fuel auxiliary engine (LNG, pilot fuel MDO, no shaft generator) which LNG could be regarded as "primary fuel" only for the dual-fuel main engine:



| S/N | Parameter                              | Formula or Source                                                           | Unit              | Value  |
|-----|----------------------------------------|-----------------------------------------------------------------------------|-------------------|--------|
| 1   | MCR <sub>MEMDO</sub>                   | MCR rating of main engine using only MDO                                    | kW                | 5,000  |
| 2   | MCR <sub>MELNG</sub>                   | MCR rating of main engine using dual-fuel                                   | kW                | 4,000  |
| 3   | Capacity                               | Deadweight of the ship at summer load draft                                 | DWT               | 81,200 |
| 4   | V <sub>ref</sub>                       | Ships speed                                                                 | kn                | 14     |
| 5   | P <sub>MEMDO</sub>                     | 0.75 x MCR <sub>MEMDO</sub>                                                 | kW                | 3,750  |
| 6   | P <sub>MELNG</sub>                     | 0.75 x MCR <sub>MELNG</sub>                                                 | kW                | 3,000  |
| 7   | P <sub>AE</sub>                        | 0.05 x (MCR <sub>MEMDO</sub> + MCR <sub>MELNG</sub> )                       | kW                | 450    |
| 8   | C <sub>F</sub> <sup>Pilotfuel</sup>    | C <sub>F</sub> factor of pilot fuel for dual-fuel ME using MDO              | -                 | 3.206  |
| 9   | C <sub>FAE</sub> <sup>Pilotfuel</sup>  | C <sub>F</sub> factor of pilot fuel for auxiliary engine using MDO          | -                 | 3.206  |
| 10  | C <sub>FLNG</sub>                      | C <sub>F</sub> factor of dual-fuel engine using LNG                         | -                 | 2.75   |
| 11  | C <sub>FMDO</sub>                      | C <sub>F</sub> factor of dual-fuel ME/AE engine using MDO                   | -                 | 3.206  |
| 12  | SFC <sub>ME</sub> <sup>Pilotfuel</sup> | Specific fuel consumption of pilot fuel for dual-fuel ME at P <sub>ME</sub> | g/kWh             | 6      |
| 13  | SFC <sub>AE</sub> <sup>Pilotfuel</sup> | Specific fuel consumption of pilot fuel for dual-fuel AE at P <sub>AE</sub> | g/kWh             | 7      |
| 14  | SFC <sub>DF</sub> <sup>LNG</sup>       | Specific fuel consumption of dual-fuel ME using LNG at P <sub>ME</sub>      | g/kWh             | 158    |
| 15  | SFC <sub>AE</sub> <sup>LNG</sup>       | Specific fuel consumption of AE using LNG at P <sub>AE</sub>                | g/kWh             | 160    |
| 16  | SFC <sub>ME</sub> <sup>MDO</sup>       | Specific fuel consumption of single fuel ME at P <sub>ME</sub>              | g/kWh             | 180    |
| 17  | V <sub>LNG</sub>                       | LNG tank capacity on board                                                  | m <sup>3</sup>    | 1,000  |
| 18  | V <sub>HFO</sub>                       | Heavy fuel oil tank capacity on board                                       | m <sup>3</sup>    | 1,200  |
| 19  | V <sub>MDO</sub>                       | Marine diesel oil tank capacity on board                                    | m <sup>3</sup>    | 400    |
| 20  | ρ <sub>LNG</sub>                       | Density of LNG                                                              | kg/m <sup>3</sup> | 450    |

| S/N | Parameter          | Formula or Source                                                                                                                                                                                                                                                                                                      | Unit                  | Value  |
|-----|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------|
| 21  | $\rho_{HFO}$       | Density of heavy fuel oil                                                                                                                                                                                                                                                                                              | kg/m <sup>3</sup>     | 991    |
| 22  | $\rho_{MDO}$       | Density of marine diesel oil                                                                                                                                                                                                                                                                                           | kg/m <sup>3</sup>     | 900    |
| 23  | LCV <sub>LNG</sub> | Low calorific value of LNG                                                                                                                                                                                                                                                                                             | kJ/kg                 | 48,000 |
| 24  | LCV <sub>HFO</sub> | Low calorific value of heavy fuel oil                                                                                                                                                                                                                                                                                  | kJ/kg                 | 40,200 |
| 25  | LCV <sub>MDO</sub> | Low calorific value of marine diesel oil                                                                                                                                                                                                                                                                               | kJ/kg                 | 42,700 |
| 26  | K <sub>LNG</sub>   | Filling rate of LNG tank                                                                                                                                                                                                                                                                                               | -                     | 0.95   |
| 27  | K <sub>HFO</sub>   | Filling rate of heavy fuel tank                                                                                                                                                                                                                                                                                        | -                     | 0.98   |
| 28  | K <sub>MDO</sub>   | Filling rate of marine diesel tank                                                                                                                                                                                                                                                                                     | -                     | 0.98   |
| 29  | f <sub>DFgas</sub> | $\frac{P_{MEMDO} + P_{MELNG} + P_{AE}}{P_{MELNG} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$ | -                     | 0.5195 |
| 30  | EEDI               | $(P_{MELNG} \times (C_F^{Pilotfuel} \times SFC_{ME Pilotfuel} + C_F^{LNG} \times SFC_{DF LNG}) + P_{MEMDO} \times C_F^{MDO} \times SFC_{ME MDO} + P_{AE} \times (C_{FAE}^{Pilotfuel} \times SFC_{AE Pilotfuel} + C_F^{LNG} \times SFC_{AE LNG})) / (V_{ref} \times Capacity)$                                          | gCO <sub>2</sub> /tnm | 3.28   |

Case 5: One dual-fuel main engine (LNG, pilot fuel MDO) and one main engine (MDO) and dual-fuel auxiliary engine (LNG, pilot fuel MDO, no shaft generator) which LNG could not be regarded as "primary fuel" for the dual-fuel main engine:



| S/N | Parameter                   | Formula or Source                                                           | Unit  | Value  |
|-----|-----------------------------|-----------------------------------------------------------------------------|-------|--------|
| 1   | MCR <sub>MEMDO</sub>        | MCR rating of main engine using only MDO                                    | kW    | 5,000  |
| 2   | MCR <sub>MELNG</sub>        | MCR rating of main engine using dual-fuel                                   | kW    | 4,000  |
| 3   | Capacity                    | Deadweight of the ship at summer load draft                                 | DWT   | 81,200 |
| 4   | V <sub>ref</sub>            | Ships speed                                                                 | kn    | 14     |
| 5   | P <sub>MEMDO</sub>          | 0.75 x MCR <sub>MEMDO</sub>                                                 | kW    | 3,750  |
| 6   | P <sub>MELNG</sub>          | 0.75 x MCR <sub>MELNG</sub>                                                 | kW    | 3,000  |
| 7   | P <sub>AE</sub>             | 0.05 x (MCR <sub>MEMDO</sub> + MCR <sub>MELNG</sub> )                       | kW    | 450    |
| 8   | C <sub>F Pilotfuel</sub>    | C <sub>F</sub> factor of pilot fuel for dual-fuel ME using MDO              | -     | 3.206  |
| 9   | C <sub>FAE Pilotfuel</sub>  | C <sub>F</sub> factor of pilot fuel for auxiliary engine using MDO          | -     | 3.206  |
| 10  | C <sub>FLNG</sub>           | C <sub>F</sub> factor of dual-fuel engine using LNG                         | -     | 2.75   |
| 11  | C <sub>FMDO</sub>           | C <sub>F</sub> factor of dual-fuel ME/AE engine using MDO                   | -     | 3.206  |
| 12  | SFC <sub>ME Pilotfuel</sub> | Specific fuel consumption of pilot fuel for dual-fuel ME at P <sub>ME</sub> | g/kWh | 6      |
| 13  | SFC <sub>AE Pilotfuel</sub> | Specific fuel consumption of pilot fuel for dual-fuel AE at P <sub>AE</sub> | g/kWh | 7      |
| 14  | SFC <sub>DF LNG</sub>       | Specific fuel consumption of dual-fuel ME using LNG at P <sub>ME</sub>      | g/kWh | 158    |

| S/N | Parameter       | Formula or Source                                                                                                                                                                                                                                                                                                                                                                                                                  | Unit                  | Value  |
|-----|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------|
| 15  | $SFC_{AE\ LNG}$ | Specific fuel consumption of AE using LNG at $P_{AE}$                                                                                                                                                                                                                                                                                                                                                                              | g/kWh                 | 160    |
| 16  | $SFC_{DF\ MDO}$ | Specific fuel consumption of dual-fuel ME using MDO at $P_{ME}$                                                                                                                                                                                                                                                                                                                                                                    | g/kWh                 | 185    |
| 17  | $SFC_{ME\ MDO}$ | Specific fuel consumption of single fuel ME at $P_{ME}$                                                                                                                                                                                                                                                                                                                                                                            | g/kWh                 | 180    |
| 18  | $SFC_{AE\ MDO}$ | Specific fuel consumption of AE using MDO at $P_{AE}$                                                                                                                                                                                                                                                                                                                                                                              | g/kWh                 | 187    |
| 19  | $V_{LNG}$       | LNG tank capacity on board                                                                                                                                                                                                                                                                                                                                                                                                         | m <sup>3</sup>        | 600    |
| 20  | $V_{HFO}$       | Heavy fuel oil tank capacity on board                                                                                                                                                                                                                                                                                                                                                                                              | m <sup>3</sup>        | 1,200  |
| 21  | $V_{MDO}$       | Marine diesel oil tank capacity on board                                                                                                                                                                                                                                                                                                                                                                                           | m <sup>3</sup>        | 400    |
| 22  | $\rho_{LNG}$    | Density of LNG                                                                                                                                                                                                                                                                                                                                                                                                                     | kg/m <sup>3</sup>     | 450    |
| 23  | $\rho_{HFO}$    | Density of heavy fuel oil                                                                                                                                                                                                                                                                                                                                                                                                          | kg/m <sup>3</sup>     | 991    |
| 24  | $\rho_{MDO}$    | Density of marine diesel oil                                                                                                                                                                                                                                                                                                                                                                                                       | kg/m <sup>3</sup>     | 900    |
| 25  | $LCV_{LNG}$     | Low calorific value of LNG                                                                                                                                                                                                                                                                                                                                                                                                         | kJ/kg                 | 48,000 |
| 26  | $LCV_{HFO}$     | Low calorific value of heavy fuel oil                                                                                                                                                                                                                                                                                                                                                                                              | kJ/kg                 | 40,200 |
| 27  | $LCV_{MDO}$     | Low calorific value of marine diesel oil                                                                                                                                                                                                                                                                                                                                                                                           | kJ/kg                 | 42,700 |
| 28  | $K_{LNG}$       | Filling rate of LNG tank                                                                                                                                                                                                                                                                                                                                                                                                           | -                     | 0.95   |
| 29  | $K_{HFO}$       | Filling rate of heavy fuel tank                                                                                                                                                                                                                                                                                                                                                                                                    | -                     | 0.98   |
| 30  | $K_{MDO}$       | Filling rate of marine diesel tank                                                                                                                                                                                                                                                                                                                                                                                                 | -                     | 0.98   |
| 31  | $f_{DFgas}$     | $\frac{P_{MEMDO} + P_{MELNG} + P_{AE}}{P_{MELNG} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$                                                                                                             | -                     | 0.3462 |
| 32  | $f_{DFliquid}$  | $1 - f_{DFgas}$                                                                                                                                                                                                                                                                                                                                                                                                                    | -                     | 0.6538 |
| 33  | EEDI            | $(P_{MELNG} \times (f_{DFgas} \times (C_{F\ Pilotfuel} \times SFC_{ME\ Pilotfuel} + C_{F\ LNG} \times SFC_{DF\ LNG}) + f_{DFliquid} \times C_{FMDO} \times SFC_{DF\ MDO})) + P_{MEMDO} \times C_{FMDO} \times SFC_{ME\ MDO} + P_{AE} \times (f_{DFgas} \times (C_{FAE\ Pilotfuel} \times SFC_{AE\ Pilotfuel} + C_{F\ LNG} \times SFC_{AE\ LNG}) + f_{DFliquid} \times C_{FMDO} \times SFC_{AE\ MDO})) / (V_{ref} \times Capacity)$ | gCO <sub>2</sub> /tnm | 3.54   |

## APPENDIX 5

## STANDARD FORMAT TO SUBMIT EEDI INFORMATION TO BE INCLUDED IN THE EEDI DATABASE

| IMO number<br>(1) | Type of ship<br>(2) | Common commercial size<br>(3) | Capacity<br>(4) |           | Dimensional parameters |               |                    | Year of delivery | Applicable phase | Required EEDI | Attained EEDI | V <sub>ref</sub> (knot)<br>(9) | P <sub>ME</sub> (kW)<br>(10) | Type of fuel<br>(11) | f <sub>DF</sub> gas<br>(12) | Ice class<br>(13) | EEDI 4th term<br>(Installation of innovative electrical technology) |                                                                   | EEDI 5th term<br>(Installation of innovative mechanical technology) |                                                                   | Short statement as appropriate describing the principal design elements or changes employed to achieve the attained EEDI<br>(15) |
|-------------------|---------------------|-------------------------------|-----------------|-----------|------------------------|---------------|--------------------|------------------|------------------|---------------|---------------|--------------------------------|------------------------------|----------------------|-----------------------------|-------------------|---------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
|                   |                     |                               | DWT             | GT<br>(5) | Lpp (m)<br>(6)         | Bs (m)<br>(7) | Draught (m)<br>(8) |                  |                  |               |               |                                |                              |                      |                             |                   | Yes/<br>No                                                          | Name, outline and means/ways of performance of technology<br>(14) | Yes/<br>No                                                          | Name, outline and means/ways of performance of technology<br>(14) |                                                                                                                                  |
|                   |                     |                               |                 |           |                        |               |                    |                  |                  |               |               |                                |                              |                      |                             |                   |                                                                     |                                                                   |                                                                     |                                                                   |                                                                                                                                  |
|                   |                     |                               |                 |           |                        |               |                    |                  |                  |               |               |                                |                              |                      |                             |                   |                                                                     |                                                                   |                                                                     |                                                                   |                                                                                                                                  |

**Note:**

- (1) IMO number to be submitted for Secretariat use only.
- (2) As defined in regulation 2 of MARPOL Annex VI.
- (3) Common commercial size reference (TEU for containership, CEU (RT43) for ro-ro cargo ship (vehicle carrier), cubic metre for gas carrier and LNG carrier), if available, should be provided.
- (4) The exact DWT or GT, as appropriate, should be provided. The Secretariat should round the DWT or GT data up to the nearest 500 when these data are subsequently provided to MEPC.  
(For containerships, 100% DWT should be provided while 70% of DWT should be used when calculating the EEDI value).
- (5) GT should be provided for a cruise passenger ship having non-conventional propulsion as defined in regulations 2.2.11 and 2.2.19, respectively, of MARPOL Annex VI.  
Both DWT and GT should be provided for a ro-ro cargo ship (vehicle carrier) as defined in regulation 2.2.27 of MARPOL Annex VI.
- (6) As defined in paragraph 2.2.13 of these Guidelines.  
The exact Lpp should be provided. The Secretariat will round the Lpp data up to the nearest 10 when these data are subsequently provided to MEPC.
- (7) As defined in paragraph 2.2.16 of these Guidelines.  
The exact Bs should be provided. The Secretariat will round the Bs data up to the nearest 1 when these data are subsequently provided to MEPC.
- (8) As defined in paragraph 2.2.15 of these Guidelines.  
The exact draught should be provided. The Secretariat will round the draught data up to the nearest 1 when these data are subsequently provided to MEPC.
- (9) As defined in paragraph 2.2.2 of these Guidelines.  
The exact V<sub>ref</sub> should be provided. The Secretariat will round the V<sub>ref</sub> data up to the nearest 0.5 when these data are subsequently provided to MEPC.
- (10) As defined in paragraph 2.2.5.1 of these Guidelines.  
The exact P<sub>ME</sub> should be provided. The Secretariat will round the P<sub>ME</sub> data up to the nearest 100 when these data are subsequently provided to MEPC.
- (11) As defined in paragraph 2.2.1 of these Guidelines or other (to be stated).  
In the case of a ship equipped with a dual-fuel engine, type of "primary fuel" should be provided.
- (12) As defined in paragraph 2.2.1 of these Guidelines, if applicable.
- (13) Ice class, which was used to calculate correction factors for ice-classed ships as defined in paragraphs 2.2.8.1 and 2.2.11.1 of these Guidelines, if applicable, should be provided.
- (14) In the case that the innovative energy efficiency technologies are already included in the *2021 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI and EEXI* (MEPC.1/Circ.896), the name of technology should be identified. Otherwise, name, outline and means/ways of performance of the technology should be identified.
- (15) To assist IMO in assessing relevant design trends, provide a short statement as appropriate, describing the principal design elements or changes employed to achieve the attained EEDI.

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