**ANNEX 14**

**RESOLUTION MEPC. 231(65)**

**Adopted on 17 May 2013**

**2013 GUIDELINES FOR CALCULATION OF REFERENCE LINES FOR USE WITH THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)**

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,

RECALLING ALSO that, at its sixty-second session, the Committee adopted, by resolution MEPC.203(62), amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (inclusion of regulations on energy efficiency for ships in MARPOL Annex VI),

NOTING that regulation 21 (required EEDI) of MARPOL Annex VI, as amended, requires reference lines to be established for each ship type to which regulation 21 is applicable,

NOTING ALSO that Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) were adopted at its sixty-third session,

HAVING CONSIDERED, at its sixty-fifth session, the draft amendments to Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI) for extension of the application of the EEDI to LNG carrier, ro-ro cargo ship (vehicle carrier), ro-ro cargo ship and ro-ro passenger ship,

1. ADOPTS the *2013 Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI)*, as set out at annex to the present resolution;

2. AGREES to keep these Guidelines under review in light of the experience gained; and

3. REVOKES the Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI), adopted by resolution MEPC.215(63), as from this date.

# 2013 GUIDELINES FOR CALCULATION OF REFERENCE LINES FOR USE WITH THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

1 The reference lines are established for each ship type to which regulation 21 (Required EEDI) of MARPOL Annex VI is applicable. The purpose of the EEDI is to provide a fair basis for comparison, to stimulate the development of more efficient ships in general and to establish the minimum efficiency of new ships depending on ship type and size. Hence, the reference lines for each ship type is calculated in a transparent and robust manner.

2 Ship types are defined in regulation 2 of MARPOL Annex VI. The reference line for each ship type is used for the determination of the required EEDI as defined in regulation 21 of MARPOL Annex VI.

3 These guidelines apply to the following ships types: bulk carrier, gas carrier, tanker, containership, general cargo ship, refrigerated cargo carrier, combination carrier, ro-ro cargo ship, ro-ro cargo ship (vehicle), ro-ro passenger ship and LNG carrier. It is noted that a method of calculating reference lines has not been established for passenger ships other than cruise passenger ship having non-conventional propulsion.

## Definition of a reference line

4 A reference line is defined as a curve representing an average index value fitted on a set of individual index values for a defined group of ships.

5 One reference line is developed for each ship type to which regulation 21 of MARPOL Annex VI is applicable, ensuring that only data from comparable ships are included in the calculation of each reference line.

6 The reference line value is formulated as $Reference\ line\ value = a\ (100\%\ deadweight)^{-c}$ where "a" and "c" are parameters determined from the regression curve fit.

7 Input data for the calculation of the reference lines is filtered through a process where data deviating more than two standard deviations from the regression line are discarded. The regression is then applied again to generate a corrected reference line. For the purpose of documentation, discarded data is listed with the ships IMO number.

## Data sources

8 IHS Fairplay (IHSF) database is selected as the standard database delivering the primary input data for the reference line calculation. For the purpose of the EEDI reference line calculations, a defined version of the database is archived as agreed between the Secretariat and IHSF.

9 For the purpose of calculating the reference lines, data relating to existing ships of 400 GT and above from the IHSF database delivered in the period from 1 January 1999 to 1 January 2009 are used. For ro-ro cargo and ro-ro passenger ships, data relating to existing ships of 400 GT and above from the IHSF database delivered in the period from 1 January 1998 to 1 January 2010 are used.

10 The following data from the IHSF database on ships with conventional propulsion systems is used when calculating the reference lines:

.1 data on the ships' capacity is used as *Capacity* for each ship type as defined in MEPC.212(63);

.2 data on the ships' service speed is used as reference speed $V_{ref}$; and

.3 data on the ships' total installed main power is used as $MCR_{ME(i)}$.

11 For some ships, some data entries may be blank or contain a zero (0) in the database. Datasets with blank power, capacity and/or speed data should be removed from the reference line calculations. For the purpose of later references, the omitted ships should be listed with their IMO number.

12 To ensure a uniform interpretation, the association of ship types defined in regulation 2 of MARPOL Annex VI, with the ship types given by the IHSF database and defined by the so-called Stat codes, is shown in the appendix to this guideline. Table 1 in the appendix 1 lists the ship types from IHSF used for the calculation of reference lines. Table 2 lists the IHSF ship types not used when calculating the reference lines.

**Calculation of reference lines**

13 To calculate the reference line, an estimated index value for each ship contained in the set of ships per ship type is calculated using the following assumptions:

.1 the carbon emission factor is constant for all engines, i.e. $C_{F,ME} = C_{F,AE} = CF$ = 3.1144 g $CO_2$/g fuel;

.2 the specific fuel consumption for all ship types is constant for all main engines, i.e. $SFC_{ME} = 190$ g/kWh;

.3 $P_{ME(i)}$ is 75% of the total installed main power ($MCR_{ME(i)}$);

.4 the specific fuel consumption for all ship types is constant for all auxiliary engines, i.e. $SFC_{AE} = 215$ g/kWh;

.5 $P_{AE}$ is the auxiliary power and is calculated according to paragraphs 2.5.6.1 and 2.5.6.2 of the annex to MEPC.212(63);

.6 for ro-ro passenger ships, $P_{AE}$ is calculated as follows:

$$P_{AE} = 0.866 \cdot GT^{0.732}$$

.7 no correction factors are used except for $f_{jRoRo}$ and $f_{cRoPax}$; and

.8 innovative mechanical energy efficiency technology, shaft motors and other innovative energy efficient technologies are all excluded from the reference line calculation, i.e. $P_{AEeff} = 0$, $P_{PTI} = 0$, $P_{eff} = 0$.

14 The equation for calculating the estimated index value for each ship (excluding containerships and ro-ro cargo ships (vehicle carrier) – see paragraph 15) is as follows:

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

15 For containerships, 70 per cent of the deadweight (70% DWT) is used as *capacity* for calculating the estimated index value for each containership as follows:

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

16 For ro-ro cargo ship (vehicle carrier), the following equation is used:

$$Estimated\ Index\ Value = f_{roroV} \cdot 3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

Where:

$$f_{roroV} = \frac{-15571 \cdot F_n^2 + 5538.4 \cdot F_n - 132.67}{287}$$

17 For ro-ro cargo ships the estimated index value for each individual ship is calculated as follows:

$$Estimated\ Index\ Value = \frac{3.1144 \cdot (f_{jRoRo} \cdot 190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

18 For ro-ro passenger ships the estimated index value for each individual ship is calculated as follows:

$$Estimated\ Index\ Value = \frac{3.1144 \cdot (\mathrm{f_{jRoRo}} \cdot 190 \cdot \sum_{i=1}^{nME} P_{MEi} + 215 \cdot P_{AE}}{f_{cRoPax} \cdot Capacity \cdot V_{ref}}$$

19 For LNG carriers, the equation set out in appendix 2 is used.

**Calculation of reference line parameters "a" and "c"**

20 For all ship types to which these guidelines apply except for ro-ro passenger ships, parameters "a" and "c" are determined from a regression analysis undertaken by plotting the calculated estimated index values against 100 per cent deadweight (100% DWT).

21 For ro-ro passenger ships, parameters "a" and "c" are determined from a regression analysis undertaken by plotting the calculated estimated index values against corrected deadweight, DWT, for ships to which the capacity correction factor, $f_{cRoPax}$, applies and against 100 per cent deadweight (100% DWT) for ships to which the capacity correction factor does not apply.

**Documentation**

22 For purposes of transparency, the ships used in the calculation of the reference lines should be listed with their IMO numbers and the numerator and denominator of the index formula, as given in paragraphs 14 to 19. The documentation of the aggregated figures preserves the individual data from direct access but offers sufficient information for possible later scrutiny.

* * *

## Appendix 1

1 To ensure a uniform interpretation, ship types defined in regulation 2 of MARPOL Annex VI are compared to the ship types given in the IHSF database.

2 The IHSF Stat code system provides several levels of definition as follows:

.1 Highest level:

| | |
|---|---|
| A | Cargo carrying |
| B | Work vessel |
| W | Non-seagoing merchant ships |
| X | Non-merchant |
| Y | Non-propelled |
| Z | Non-ship structures |

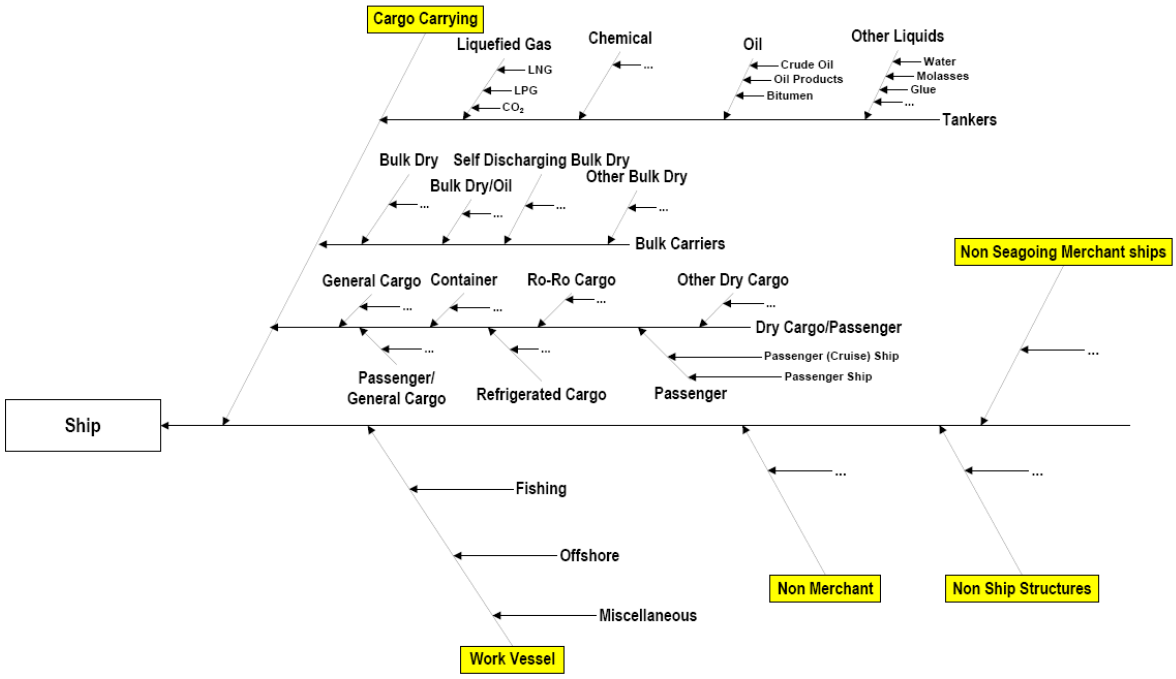
For the purpose of the EEDI, only group "A cargo carrying" needs to be considered. A graphical representation of this is given below.

.2 The next level comprises:

| | |
|---|---|
| A1 | Tankers |
| A2 | Bulk carriers |
| A3 | Dry cargo/passenger |

There are further differentiations until level five, e.g. "A31A2GX General Cargo Ship", and each category is described.

The complete list is attached.



3 The ship types from the IHSF Stat code 5 (Statcode5v1075) used for the calculation of reference lines for the following ship types: bulk carrier, gas carrier, tanker, containership, general cargo ship, refrigerated cargo carrier and combination carrier, are set out in table 1. The IHSF database ship types, not used in the calculation of reference lines for the specific ship types, are set out in table 2, e.g. ships built for sailing on the Great Lakes and landing craft.

**Table 1: Ship types from IHSF used for the calculation of reference lines for use with the EEDI**

| | | | | |
|---|---|---|---|---|
| .1 Bulk carrier | Bulk dry | A21A2BC | Bulk carrier | A single deck cargo vessel with an arrangement of topside ballast tanks for the carriage of bulk dry cargo of a homogeneous nature. |
| | Bulk dry | A21B2BO | Ore carrier | A single deck cargo ship fitted with two longitudinal bulkheads. Ore is carried in the centreline holds only. |
| | Self-discharging bulk dry | A23A2BD | Bulk cargo carrier, self-discharging | A bulk carrier fitted with self-trimming holds, a conveyor belt (or similar system) and a boom which can discharge cargo alongside or to shore without the assistance of any external equipment. |
| | Other dry bulk | A24A2BT | Cement carrier | A single deck cargo vessel fitted with pumping arrangements for the carriage of cement in bulk. There are no weather deck hatches. May be self-discharging. |
| | | A24B2BW | Wood chips carrier, self-unloading | A single deck cargo vessel with high freeboard for the carriage of wood chips. May be self-discharging. |
| | | A24C2BU | Urea carrier | A single deck cargo vessel for the carriage of urea in bulk. May be self-discharging. |
| | | A24D2BA | Aggregates carrier | A single deck cargo vessel for the carriage of aggregates in bulk. Also known as a sand carrier. May be self-discharging. |
| | | A24E2BL | Limestone carrier | A single deck cargo vessel for the carriage of limestone in bulk. There are no weather deck hatches. May be self-discharging. |
| .2 Gas carrier | Liquefied gas | A11A2TN | LNG tanker | A tanker for the bulk carriage of liquefied natural gas (primarily methane) in independent insulated tanks. Liquefaction is achieved at temperatures down to -163 deg C. |
| | | A11B2TG | LPG tanker | A tanker for the bulk carriage of liquefied petroleum gas in insulated tanks, which may be independent or integral. The cargo is pressurized (smaller vessels), refrigerated (larger vessels) or both ("semi-pressurized") to achieve liquefaction. |
| | | A11C2LC | $CO_2$ tanker | A tanker for the bulk carriage of liquefied carbon dioxide. |
| | | A11A2TQ | CNG tanker | A tanker for the bulk carriage of compressed natural gas. Cargo remains in gaseous state but is highly compressed. |

| | | | | |
|---|---|---|---|---|
| .3 Tanker | Chemical | A12A2LP | Molten sulphur tanker | A tanker for the bulk carriage of molten sulphur in insulated tanks at a high temperature. |
| | | A12A2TC | Chemical tanker | A tanker for the bulk carriage of chemical cargoes, lube oils, vegetable/animal oils and other chemicals as defined in the International Bulk Chemical Code. Tanks are coated with suitable materials which are inert to the cargo. |
| | | A12B2TR | Chemical/ products tanker | A chemical tanker additionally capable of the carriage of clean petroleum products. |
| | | A12C2LW | Wine tanker | A cargo ship designed for the bulk transport of wine in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers. |
| | | A12D2LV | Vegetable oil tanker | A cargo ship designed for the bulk transport of vegetable oils in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers. |
| | | A12E2LE | Edible oil tanker | A cargo ship designed for the bulk transport of edible oils in tanks. Tanks will be stainless steel or lined. New vessels will be classified as chemical carriers. |
| | | A12F2LB | Beer tanker | A tanker for the bulk carriage of beer. |
| | | A12G2LT | Latex tanker | A tanker for the bulk carriage of latex. |
| | | A12H2LJ | Fruit juice tanker | A tanker for the bulk carriage of fruit juice concentrate in insulated tanks. |
| | Oil | A13A2TV | Crude oil tanker | A tanker for the bulk carriage of crude oil. |
| | | A13A2TW | Crude/oil products tanker | A tanker for the bulk carriage of crude oil but also for carriage of refined oil products. |
| | | A13B2TP | Products tanker | A tanker for the bulk carriage of refined petroleum products, either clean or dirty. |
| | | A13B2TU | Tanker (unspecified) | A tanker whose cargo is unspecified. |
| | | A13C2LA | Asphalt/ Bitumen tanker | A tanker for the bulk carriage of asphalt/bitumen at temperatures between 150 and 200 deg C. |
| | | A13E2LD | Coal/oil mixture tanker | A tanker for the bulk carriage of a cargo of coal and oil mixed as a liquid and maintained at high temperatures. |
| | Other liquids | A14A2LO | Water tanker | A tanker for the bulk carriage of water. |
| | | A14F2LM | Molasses tanker | A tanker for the bulk carriage of molasses. |
| | | A14G2LG | Glue tanker | A tanker for the bulk carriage of glue. |
| | | A14H2LH | Alcohol tanker | A tanker for the bulk carriage of alcohol. |
| | | A14N2LL | Caprolactam tanker | A tanker for the bulk carriage of caprolactam, a chemical used in the plastics industry for the production of polyamides. |
| | Chemical | A12A2TL | Parcels tanker | A chemical tanker with many segregated cargo tanks to carry multiple grades of chemicals as defined in the International Bulk Chemical Code. Typically these can have between 10 and 60 different tanks. |

| | | | | |
|---|---|---|---|---|
| .4 Containership | Container | A33A2CC | Containership (fully cellular) | A single deck cargo vessel with boxed holds fitted with fixed cellular guides for the carriage of containers. |
| .5 General cargo ship | General cargo | A31A2GX | General cargo ship | A single or multi-deck cargo vessel for the carriage of various types of dry cargo. Single deck vessels will typically have box-shaped holds. Cargo is loaded and unloaded through weather deck hatches. |
| | Other dry cargo | A38H2GU | Pulp carrier | A vessel designed for carrying paper pulp. |
| .6 Refrigerated cargo carrier | Refrigerated cargo | A34A2GR | Refrigerated cargo ship | A multi-deck cargo ship for the carriage of refrigerated cargo at various temperatures. |
| .7 Combination carrier | Bulk dry/oil | A22A2BB | Bulk/oil carrier (OBO) | A bulk carrier arranged for the alternative (but not simultaneous) carriage of crude oil. |
| | Bulk dry/oil | A22B2BR | Ore/oil carrier | An ore carrier arranged for the alternative (but not simultaneous) carriage of crude oil. |
| | Bulk dry/oil | A22A2BP | Ore/bulk/ products carrier | A bulk carrier arranged for the alternative (but not simultaneous) carriage of oil products. |

**Table 2: Ship types from IHSF not included in the calculation of reference lines for use with the EEDI**

| | | | | |
|---|---|---|---|---|
| .1 Bulk carrier | Bulk dry | A21A2BG | Bulk carrier, laker only | A single deck cargo vessel with dimensions suited to the limitations of Great Lakes of North America trade, unsuitable for open sea navigation. Hatches are more numerous than standard bulk carriers, and much wider than they are long. |
| | Bulk dry | A21A2BV | Bulk carrier (with vehicle decks) | A bulk carrier with movable decks for the additional carriage of new vehicles. |
| | Bulk dry/oil | A22A2BB | Bulk/oil carrier (OBO) | A bulk carrier arranged for the alternative (but not simultaneous) carriage of crude oil. |
| | Bulk dry/oil | A22B2BR | Ore/oil carrier | An ore carrier arranged for the alternative (but not simultaneous) carriage of crude oil. |
| | Bulk dry/oil | A22A2BP | Ore/bulk/products carrier | A bulk carrier arranged for the alternative (but not simultaneous) carriage of oil products. |
| | Self-discharging bulk dry | A23A2BK | Bulk cargo carrier, self-discharging, laker | A Great Lakes bulk carrier fitted with a conveyor belt (or similar system) and a boom which can discharge cargo alongside or to shore without the assistance of any external equipment. |
| | Other bulk dry | A24H2BZ | Powder carrier | A single deck cargo vessel for the carriage of fine powders such as fly ash. There are no weather deck hatches. |
| | Other bulk dry | A24G2BS | Refined sugar carrier | A single deck cargo vessel for the carriage of refined sugar. Sugar is loaded in bulk and bagged in transit (BIBO – Bulk In – Bag Out). |
| .2 Gas carrier | Liquefied gas | A11B2TH | LPG/chemical tanker | An LPG tanker additionally capable of the carriage of chemical products as defined in the International Bulk Chemical Code. |
| .3 Tanker | Oil | A13A2TS | Shuttle tanker | A tanker for the bulk carriage of crude oil specifically for operation between offshore terminals and refineries. Is typically fitted with bow loading facilities. |
| .4 Containership | Container | A33B2CP | Passenger/ containership | A containership with accommodation for the carriage of more than 12 passengers. |

| | | | | |
|---|---|---|---|---|
| .5 General cargo ship | General cargo | A31A2GO | Open hatch cargo ship | A large single deck cargo vessel with full width hatches and boxed holds for the carriage of unitized dry cargo such as forest products and containers. Many are fitted with a gantry crane. |
| | General cargo | A31A2GS | General cargo/tanker (container/oil/bulk – COB ship) | A general cargo ship with reversible hatch covers; one side is flush and the other is fitted with baffles for use with liquid cargoes. Containers can be carried on the hatch covers in dry cargo mode. |
| | General cargo | A31A2GT | General cargo/tanker | A general cargo ship fitted with tanks for the additional carriage of liquid cargo. |
| | General cargo | A31C2GD | Deck cargo ship | A vessel arranged for carrying unitized cargo on deck only. Access may be by use of a ro-ro ramp. |
| | Passenger/general cargo | A32A2GF | General cargo/ passenger ship | A general cargo ship with accommodation for the carriage of more than 12 passengers. |
| | Other dry cargo | A38A2GL | Livestock carrier | A cargo vessel arranged for the carriage of livestock. |
| | Other dry cargo | A38B2GB | Barge carrier | A cargo vessel arranged for the carriage of purpose built barges (lighters) loaded with cargo. Typically loading is by way of a gantry crane. Also known as Lighter Aboard SHip vessels (LASH). |
| | Other dry cargo | A38C3GH | Heavy load carrier, semi-submersible | A heavy load carrier which is semi-submersible for the float on loading/unloading of the cargoes. |
| | Other dry cargo | A38C3GY | Yacht carrier, semi-submersible | A semi-submersible heavy load carrier specifically arranged for the carriage of yachts. |
| | Other dry cargo | A38D2GN | Nuclear fuel carrier | A cargo vessel arranged to carry nuclear fuel in flasks. |
| | Other dry cargo | A38D2GZ | Nuclear fuel carrier (with ro-ro facility) | A nuclear fuel carrier which is loaded and unloaded by way of a ro-ro ramp. |
| | Other dry cargo | A38B3GB | Barge carrier, semi-submersible | A barge carrier which is semi-submersible for the float on loading/unloading of the barges. |
| | Other dry cargo | A38C2GH | Heavy load carrier | A cargo vessel able to carry heavy and/or outsized individual cargoes. Cargo may be carried on deck or in holds and may be loaded by crane and/or ro-ro ramps. |

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## Appendix 2

## EQUATION FOR CALCULATING THE INDEX VALUE OF REFERENCE LINE FOR LNG CARRIERS

| | Direct Drive Diesel | Dual Fuel Diesel – Electronic (DFDE) | Steam Turbine |
|---|---|---|---|
| **Margins** | $Engine: 10\%$<br>$Sea: 20\%$ | $Engine: -$<br>$Sea: 20\%$ | $Engine: -$<br>$Sea: 20\%$ |
| **Design Margin** | $M \arg in = \frac{0.9}{1.2}$<br>$M \arg in = 75\%$ | $M \arg in = \frac{1}{1.2}$<br>$M \arg in = 83\%$ | $M \arg in = \frac{1}{1.2}$<br>$M \arg in = 83\%$ |
| **$P_{ME}$ Formula**[1] | $P_{ME(i)} = 0.75 \cdot \left(MCR_{ME(i)} - P_{PTO(i)}\right)$ | $P_{ME(i)} = 0.83 \cdot \frac{MPP_{(i)}}{\eta_{Electrical(i)}}$ | $P_{ME(i)} = 0.83 \cdot \left(MCR_{ME(i)} - P_{PTO(i)}\right)$ |
| **$SFC_{ME}$ in g/kWh (Fuel)** | 190 ($HFO$) | 175 ($FBO$) | 285 ($FBO$) |
| **$P_{AE}$ Formula**[2] | $P_{AE} = 0.025 \cdot \sum_{i=1}^{nME} MCR_{ME(i)} + 250 + Capacity \cdot BOR \cdot 15$ | $P_{AE} = (0.025 + 0.02) \cdot \sum_{i=1}^{nME} P_{ME(i)} + 250$ | $P_{AE} = 0$ |
| **Index Formulae** | $3.1144 \cdot \frac{190 \cdot \sum_{i=1}^{nME} P_{ME(i)} + 215 \cdot P_{AE}}{Capacity \cdot V_{ref}}$ | $2.75 \cdot \frac{175 \cdot \sum_{i=1}^{nME} P_{ME(i)} + 175 \cdot P_{AE}}{Capacity \cdot V_{ref}}$ | $2.75 \cdot \frac{285 \cdot \sum_{i=1}^{nME} P_{ME(i)}}{Capacity \cdot V_{ref}}$ |

**NOTES:**

1 $MPP_{(i)}$ of DFDE is calculated as 66% of MCR of engines.

2 BOR of Direct Drive Diesel is 0.15 (%/day).

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