

**ANNEX 9**

**RESOLUTION MEPC.281(70)  
(Adopted on 28 October 2016)**

**AMENDMENTS TO THE 2014 GUIDELINES ON THE METHOD OF CALCULATION  
OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS  
(RESOLUTION MEPC.245(66), AS AMENDED BY RESOLUTION MEPC.263(68))**

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,

RECALLING ALSO that it 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 the aforementioned amendments to MARPOL Annex VI entered into force on 1 January 2013,

NOTING ALSO that regulation 20 (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 the *2012 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, adopted by resolution MEPC.212(63), and, the amendments thereto, adopted by resolution MEPC.224(64),

NOTING FURTHER that it adopted, by resolution MEPC.245(66), the *2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, and by resolution MEPC.263(68), amendments thereto,

RECOGNIZING that the aforementioned amendments to MARPOL Annex VI require relevant guidelines for the smooth and uniform implementation of the regulations,

HAVING CONSIDERED, at its seventieth session, proposed amendments to the *2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, as amended,

1 ADOPTS amendments to the *2014 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, as amended, as set out in the annex to the present resolution;

2 INVITES Administrations to take the aforementioned amendments into account when developing and enacting national laws which give force to and implement provisions set forth in regulation 20 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 the light of experience gained with their implementation.

ANNEX

**AMENDMENTS TO THE 2014 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS (RESOLUTION MEPC.245(66), AS AMENDED BY RESOLUTION MEPC.263(68))**

1 The following text is added after 2.12.3 in the table of contents:

"2.12.4  $f_c$  bulk carriers designed to carry light cargoes; wood chip carriers"

2 Paragraph 2.1 is replaced with the following:

".1  $C_F$  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 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 Liquefied Natural Gas (LNG)		48,000	0.7500	2.750
6 Methanol		19,900	0.3750	1.375
7 Ethanol		26,800	0.5217	1.913

In 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, gas fuel should be identified whether it is regarded as the "primary fuel" in accordance with the formula below:

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

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  $m^3$ . 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 to  $V_{gas}$  if it is connected to the fuel gas supply system (FGSS);

$V_{liquid}$  is the total net liquid fuel capacity on board in  $m^3$  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  $kg/m^3$ ;

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

$LCV_{gas}$  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.

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

- 3 The following sentences are added at the end of existing paragraph 2.7.1:

"Reference lower calorific values of additional fuels are given in the table in paragraph 2.1 of these Guidelines. The reference lower calorific value corresponding to the conversion factor of the respective fuel should be used for calculation."

4 A new paragraph 2.12.4 is added after the existing paragraph 2.12.3 as follows:

"4 For bulk carriers having  $R$  of less than 0.55 (e.g. wood chip carriers), the following cubic capacity correction factor,  $f_c$  bulk carriers designed to carry light cargoes, should apply:

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

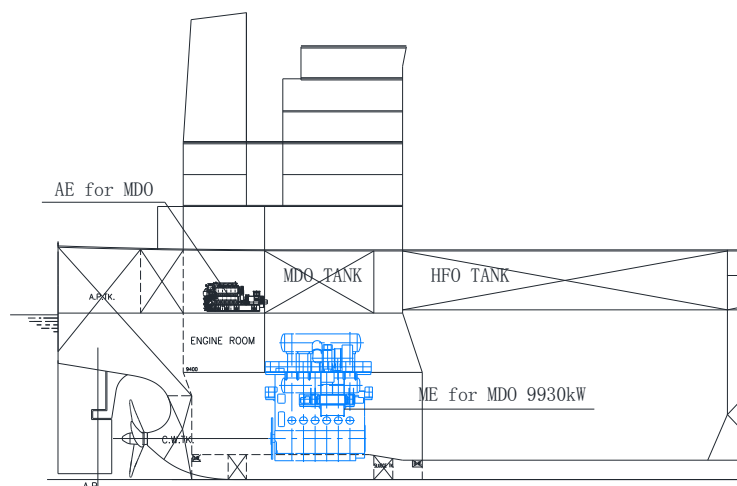
where:  $R$  is the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 2.4 divided by the total cubic capacity of the cargo holds of the ship (m<sup>3</sup>)."

5 Appendix 4 is replaced with the following:

#### "APPENDIX 4

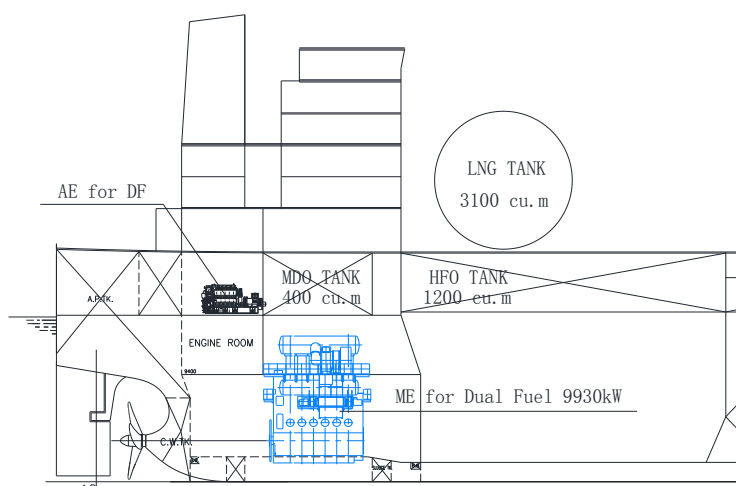
### EEDI CALCULATION EXAMPLES FOR USE OF DUAL FUEL ENGINES

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



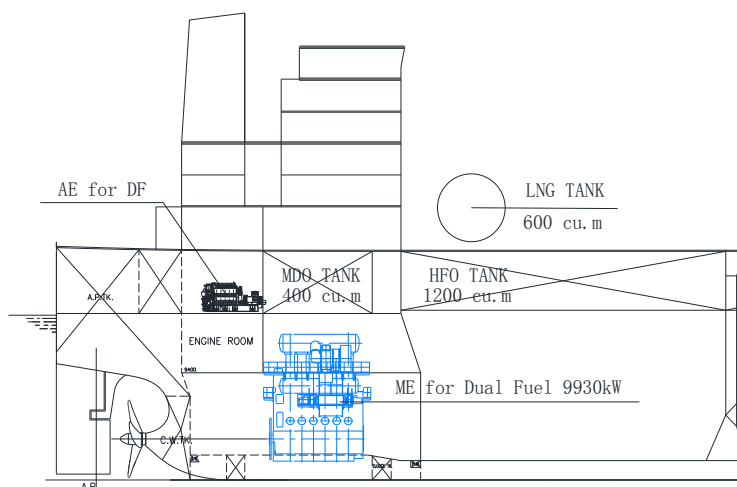
S/N	Parameter	Formula or Source	Unit	Value
1	$MCR_{ME}$	MCR rating of main engine	kW	9930
2	Capacity	Deadweight of the ship at summer load draft	DWT	81200
3	$V_{ref}$	Ships speed as defined in EEDI regulation	kn	14
4	$P_{ME}$	$0.75 \times MCR_{ME}$	kW	7447.5
5	$P_{AE}$	$0.05 \times MCR_{ME}$	kW	496.5
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	$((P_{ME} \times C_{FME} \times SFC_{ME}) + (P_{AE} \times C_{FAE} \times SFC_{AE})) / (V_{ref} \times Capacity)$	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	9930
2	Capacity	Deadweight of the ship at summer load draft	DWT	81200
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	7447.5
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>MEPilotfuel</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>	3100
14	V <sub>HFO</sub>	Heavy fuel oil tank capacity on board	m <sup>3</sup>	1200
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	48000
20	LCV <sub>HFO</sub>	Low calorific value of heavy fuel oil	kJ/kg	40200
21	LCV <sub>MDO</sub>	Low calorific value of marine diesel oil	kJ/kg	42700
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

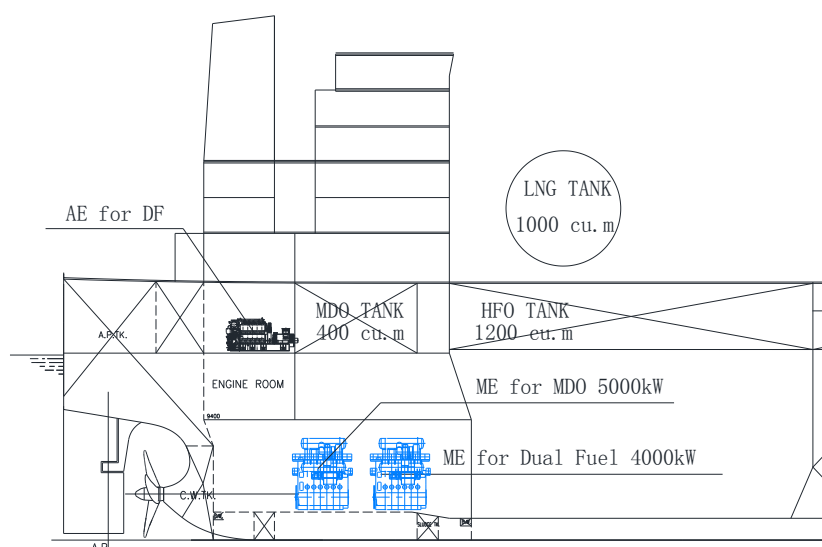
Case 3: LNG is not regarded as the "primary fuel" if dual-fuel main engine and dual-fuel auxiliary engine (LNG, pilot fuel MDO; no shaft generator) are equipped with smaller LNG tanks



S/N	Parameter	Formula or Source	Unit	Value
1	$MCR_{ME}$	MCR rating of main engine	kW	9930
2	Capacity	Deadweight of the ship at summer load draft	DWT	81200
3	$V_{ref}$	Ships speed as defined in EEDI regulation	kn	14
4	$P_{ME}$	$0.75 \times MCR_{ME}$	kW	7447.5
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	$SFC_{AEPilotfuel}$	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	$SFC_{MEMDO}$	Specific fuel consumption of dual fuel ME using MDO at $P_{ME}$	g/kWh	165
15	$SFC_{AEMDO}$	Specific fuel consumption of dual fuel AE using MDO at $P_{AE}$	g/kWh	187
16	$V_{LNG}$	LNG tank capacity on board	$m^3$	600
17	$V_{HFO}$	Heavy fuel oil tank capacity on board	$m^3$	1800
18	$V_{MDO}$	Marine diesel oil tank capacity on board	$m^3$	400
19	$\rho_{LNG}$	Density of LNG	$kg/m^3$	450
20	$\rho_{HFO}$	Density of heavy fuel oil	$kg/m^3$	991
21	$\rho_{MDO}$	Density of Marine diesel oil	$kg/m^3$	900
22	$LCV_{LNG}$	Low calorific value of LNG	$kJ/kg$	48000
24	$LCV_{HFO}$	Low calorific value of heavy fuel oil	$kJ/kg$	40200
25	$LCV_{MDO}$	Low calorific value of marine diesel oil	$kJ/kg$	42700
26	$K_{LNG}$	Filling rate of LNG tank	-	0.95
27	$K_{HFO}$	Filling rate of heavy fuel tank	-	0.98

S/N	Parameter	Formula or Source	Unit	Value
28	$K_{MDO}$	Filling rate of marine diesel tank	-	0.98
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.

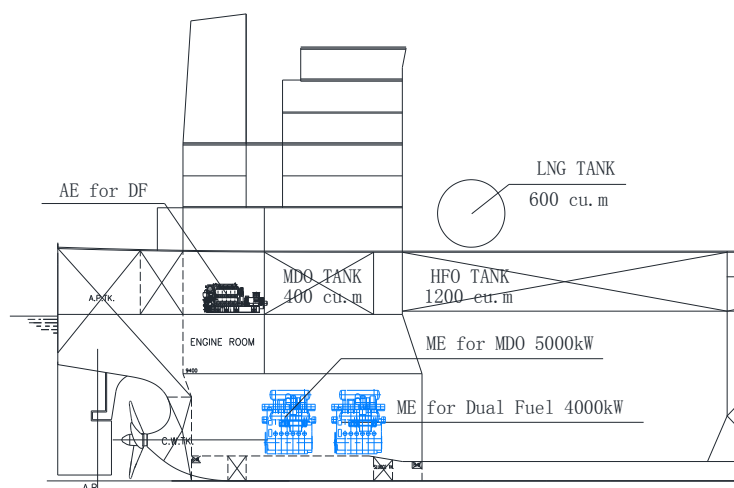


S/N	Parameter	Formula or Source	Unit	Value
1	$MCR_{MEMDO}$	MCR rating of main engine using only MDO	kW	5000
2	$MCR_{MELNG}$	MCR rating of main engine using dual fuel	kW	4000
3	Capacity	Deadweight of the ship at summer load draft	DWT	81200
4	$V_{ref}$	Ships speed	kn	14
5	$P_{MEMDO}$	$0.75 \times MCR_{MEMDO}$	kW	3750
6	$P_{MELNG}$	$0.75 \times MCR_{MELNG}$	kW	3000
7	$P_{AE}$	$0.05 \times (MCR_{MEMDO} + MCR_{MELNG})$	kW	450
8	$C_{FPilotfuel}$	$C_F$ factor of pilot fuel for dual fuel ME using MDO	-	3.206
9	$C_{FAE Pilotfuel}$	$C_F$ factor of pilot fuel for Auxiliary engine using MDO	-	3.206
10	$C_{FLNG}$	$C_F$ factor of dual fuel engine using LNG	-	2.75
11	$C_{FMDO}$	$C_F$ factor of dual fuel ME/AE engine using MDO	-	3.206
12	$SFC_{MEPilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel ME at $P_{ME}$	g/kWh	6
13	$SFC_{AE Pilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel AE at $P_{AE}$	g/kWh	7
14	$SFC_{DF LNG}$	Specific fuel consumption of dual fuel ME using LNG at $P_{ME}$	g/kWh	158
15	$SFC_{AE LNG}$	Specific fuel consumption of AE using LNG at $P_{AE}$	g/kWh	160
16	$SFC_{ME MDO}$	Specific fuel consumption of single fuel ME at $P_{ME}$	g/kWh	180
17	$V_{LNG}$	LNG tank capacity on board	m <sup>3</sup>	1000
18	$V_{HFO}$	Heavy fuel oil tank capacity on board	m <sup>3</sup>	1200



S/N	Parameter	Formula or Source	Unit	Value
19	$V_{MDO}$	Marine diesel oil tank capacity on board	$m^3$	400
20	$\rho_{LNG}$	Density of LNG	$kg/m^3$	450
21	$\rho_{HFO}$	Density of heavy fuel oil	$kg/m^3$	991
22	$\rho_{MDO}$	Density of Marine diesel oil	$kg/m^3$	900
23	$LCV_{LNG}$	Low calorific value of LNG	$kJ/kg$	48000
24	$LCV_{HFO}$	Low calorific value of heavy fuel oil	$kJ/kg$	40200
25	$LCV_{MDO}$	Low calorific value of marine diesel oil	$kJ/kg$	42700
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 Lmarine diesel tank	-	0.98
29	$f_{DFgas}$	$\frac{P_{MEMDO} + P_{MELNG} + P_{AE}}{P_{MELNG} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$	-	0.5195
30	EEDI	$(P_{MELNG} \times (C_F^{Pilotfuel} \times SFC_{ME Pilotfuel} + C_F^{LNG} \times SFC_{DF LNG}) + P_{MEMDO} \times C_F^{MDO} \times SFC_{ME MDO} + P_{AE} \times (C_{FAE}^{Pilotfuel} \times SFC_{AE Pilotfuel} + C_F^{LNG} \times SFC_{AE LNG})) / (V_{ref} \times Capacity)$	$gCO_2/tnm$	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	$MCR_{MEMDO}$	MCR rating of main engine using only MDO	$kW$	5000
2	$MCR_{MELNG}$	MCR rating of main engine using dual fuel	$kW$	4000
3	Capacity	Deadweight of the ship at summer load draft	DWT	81200
4	$V_{ref}$	Ships speed	$kn$	14
5	$P_{MEMDO}$	$0.75 \times MCR_{MEMDO}$	$kW$	3750
6	$P_{MELNG}$	$0.75 \times MCR_{MELNG}$	$kW$	3000
7	$P_{AE}$	$0.05 \times (MCR_{MEMDO} + MCR_{MELNG})$	$kW$	450
8	$C_F^{Pilotfuel}$	$C_F$ factor of pilot fuel for dual fuel ME using MDO	-	3.206
9	$C_{FAE}^{Pilotfuel}$	$C_F$ factor of pilot fuel for Auxiliary engine using MDO	-	3.206
10	$C_{FLNG}$	$C_F$ factor of dual fuel engine using LNG	-	2.75
11	$C_{FMDO}$	$C_F$ factor of dual fuel ME/AE engine using MDO	-	2.75
12	$SFC_{ME Pilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel ME at $P_{ME}$	$g/kWh$	6
13	$SFC_{AE Pilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel AE at $P_{AE}$	$g/kWh$	7

S/N	Parameter	Formula or Source	Unit	Value
14	SFC <sub>DF LNG</sub>	Specific fuel consumption of dual fuel ME using LNG at P <sub>ME</sub>	g/kWh	158
15	SFC <sub>AE LNG</sub>	Specific fuel consumption of AE using LNG at P <sub>AE</sub>	g/kWh	160
16	SFC <sub>DF MDO</sub>	Specific fuel consumption of dual fuel ME using MDO at P <sub>ME</sub>	g/kWh	185
17	SFC <sub>ME MDO</sub>	Specific fuel consumption of single fuel ME at P <sub>ME</sub>	g/kWh	180
18	SFC <sub>AE MDO</sub>	Specific fuel consumption of AE using MDO at P <sub>AE</sub>	g/kWh	187
19	V <sub>LNG</sub>	LNG tank capacity on board	m <sup>3</sup>	600
20	V <sub>HFO</sub>	Heavy fuel oil tank capacity on board	m <sup>3</sup>	1200
21	V <sub>MDO</sub>	Marine diesel oil tank capacity on board	m <sup>3</sup>	400
22	ρ <sub>LNG</sub>	Density of LNG	kg/m <sup>3</sup>	450
23	ρ <sub>HFO</sub>	Density of heavy fuel oil	kg/m <sup>3</sup>	991
24	ρ <sub>MDO</sub>	Density of Marine diesel oil	kg/m <sup>3</sup>	900
25	LCV <sub>LNG</sub>	Low calorific value of LNG	kJ/kg	48000
26	LCV <sub>HFO</sub>	Low calorific value of heavy fuel oil	kJ/kg	40200
27	LCV <sub>MDO</sub>	Low calorific value of marine diesel oil	kJ/kg	42700
28	K <sub>LNG</sub>	Filling rate of LNG tank	-	0.95
29	K <sub>HFO</sub>	Filling rate of heavy fuel tank	-	0.98
30	K <sub>MDO</sub>	Filling rate of marine diesel tank	-	0.98
31	f <sub>DFgas</sub>	$\frac{P_{MEMDO} + P_{MELNG} + P_{AE}}{P_{MELNG} + P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$	-	0.3462
32	f <sub>DFliquid</sub>	1- f <sub>DFgas</sub>	-	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

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