CCS Rule Change Notice For:

RULES FOR GREEN SHIPS

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Effective from 1 July, 2019

Beijing

APPENDIX 1 GUIDELINES FOR CALCULATION OF THE ATTAINED EEDI

The EEDI Formula in section 2 is replaced with the following:

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

Paragraph 3 is substituted by the following:

3 Definition and selection of parameters in Attained EEDI calculation formula

3.1 Carbon conversion factor (C_F)

C_F is a non-dimensional conversion factor between fuel consumption and CO_2 emission based on carbon content, measured in t-CO_2/t-Fuel. The subscripts *Mei* and *AEi* 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 NO_x Technical Code (hereinafter referred to as "test report included in a NO_x technical file").The value of C_F is as follows:

Carbon Conversion Factor C_F Table 3.1

Type of fuel	Reference	Lower calorific value（kJ/kg）	Carbon content	C_F (t-CO_2/t-Fuel)
1. Diesel/gas oil	ISO 8217 Grades DMX through DMC	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 are to apply and be multiplied with the specific fuel oil consumption of each fuel at the relevant EEDI load point. Meanwhile, gas fuel is to be identified whether it is regarded as the "primary fuel" in accordance with the formula below:

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

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

where ：

f_{DFgas} is the fuel availability ratio of gas fuel corrected for the power ratio of gas engines to total engines, f_{DFgas} is not to 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 refueling are used, the capacity of the whole LNG fuelling system is to 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;

ρ_{gas} is the density of gas fuel in kg/m^3;

ρ_{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 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) are to 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 $P_{ME(i)}\ C_{FME(i)}\ SFC_{ME(i)}$ in the EEDI calculation is to be replaced by the formula below:

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

Paragraph 3.5.4(4) is substituted by the following:

(4)For ship where the P_{AE} value calculated by (1), (2) or (3) above is significantly different from the total power used at the speed V_{ref}, e.g., in cases of Passenger ships, Ro-Ro Passenger Ships and Cruise Passenger Ships, the P_{AE} value is to be estimated by the consumed electric power (excluding propulsion) in conditions when the ship is engaged in a voyage at the reference speed (V_{ref}) as given in the electric power table, divided by the average efficiency of the generator(s) weighted by power. As an option for other vessel types, if the difference between P_{AE} value calculated by (1), (2) or (3) above and P_{AE} based on electric power table, leads to a variation of the computed EEDI value exceeding 1%, the value for auxiliary power could be taken from the electric power table.

The electric power table for EEDI calculation is to be examined and validated by CCS. Where ambient conditions affect any electrical load in the power table, the contractual ambient conditions leading to the maximum design electrical load of the installed system for the ship in general are to apply. See appendix 2 for the development of electric power tables.

A new paragraph of 3.7.11 is added as follows:

3.7.11Reference lower calorific values of additional fuels are given in the Table 3.1 of these Guidelines. The reference lower calorific value corresponding to the conversion factor of the respective fuel is to be used for calculation.

Table 3.8.1 is substituted by the following:

Correction factor for power f_j for ice-classed ships **Table 3.8.1**

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	$\frac{5.598 \cdot DWT^{0.696}}{\sum_{i=1}^{nME} MCR_{ME(i)}}$	$0.5254 \cdot DWT^{0.0357}$	$0.6325 \cdot DWT^{0.0278}$	$0.7670 \cdot DWT^{0.0159}$	$0.8918 \cdot DWT^{0.0079}$

A new paragraph after 3.8.1 is added as follows:

Alternatively, if an ice-class ship is designed and constructed based on an open water ship with same

shape and size of hull with EEDI certification, the power correction factor, f_i, 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:
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 3.5.

Paragraph 3.9.1 is substituted by the following:

For ice-classed ships, the capacity is decreased due to the increased ship weight resulting from the increased steel plate thickness for guaranteeing their ice breaking capability. Therefore this capacity correction factor is applied to compensate for the loss of capacity. The capacity correction factor, fi, for ice-classed ships having DWT as the measure of capacity should be calculated as follows:

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

where $f_{i(ice\ class)}$ is the capacity correction factor for ice-strengthening of the ship, which can be obtained from Table 3.9.1（1） and f_{iCb} 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:

$$f_{iC_b} = \frac{C_{breferencedesign}}{C_b},$$

Capacity correction factor for ice-strengthening of the hull Table 3.9.1（1）

Ice	$f_{i(ice\ class)}$
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	$f_{i(IAS)} = 1.0151 + 228.7/DWT$

where $C_{b\ reference\ design}$ is the average block coefficient for the ship type, which can be obtained from Table 3.9.1（2）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,

$$f_{iC_b} = 1.0$$

Average block coefficients $C_{b\ reference\ design}$ for bulk carriers, tankers and general cargo ships
Table 3.9.1（2）

Ship type	Size categories				
	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_{iVSE}) in paragraph 3.9.2. This formula can also be used for other ice classes than those given in Table 3.9.1（1）.

A new paragraph 3.10.4 is added as follows:

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

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

where: R— the capacity ratio of the deadweight of the ship (tonnes) as determined by paragraph 3.4 divided by the total cubic capacity of the cargo holds of the ship (m^3).

A new section 3.19 is added after the existing section 3.18 as follows:

3.19 Factor for ice-classed ships having IA Super and IA, f_m

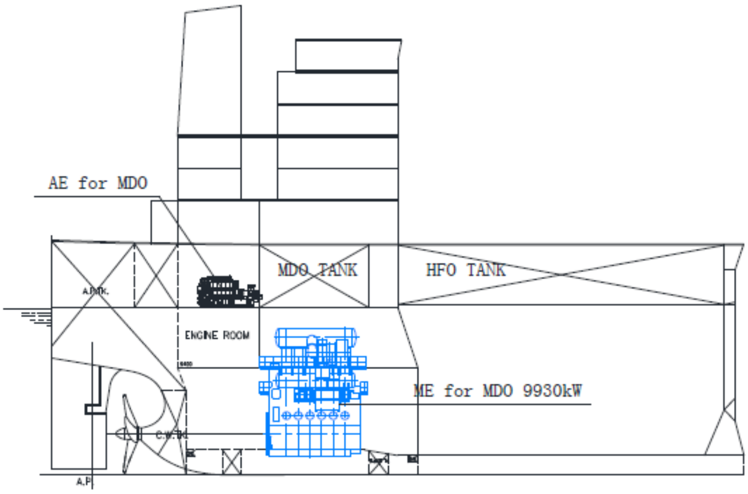
For ice-classed ships having IA Super or IA, the following factor, f_m, should apply:

$$f_m = 1.05$$

The existing Appendix 1-1 is substituted by the following:

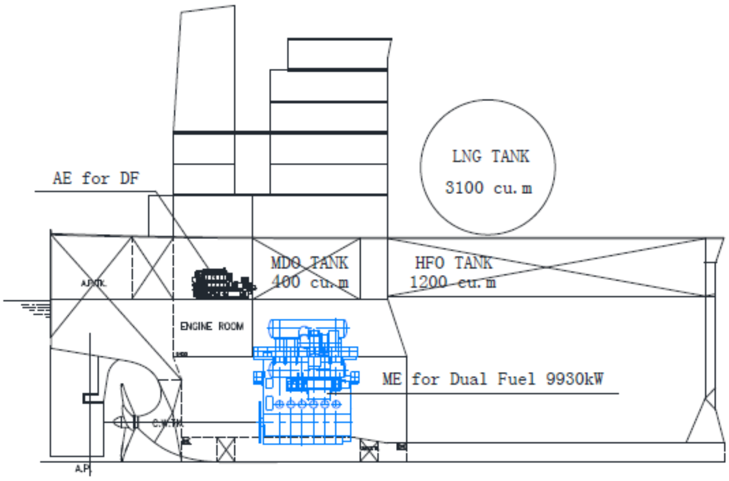
Appendix 1-1 EEDI Calculation Examples for Use of Dual Fuel Engines

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}	MCRrating 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 ME at P_{ME}	g/kWh	165
9	SFC_{AE}	Specific fuel consumption of AE at P_{AE}	g/kWh	210
10	EEDI	$[(P_{ME} \times C_{F\,ME} \times SFC_{ME})+(P_{AE} \times C_{FAE} \times SFC_{AE})] / (V_{ref} \times Capacity)$	gCO_2/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
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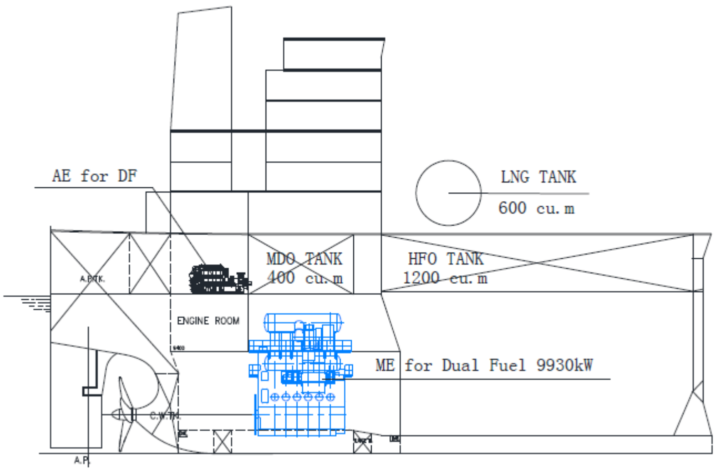
4	P_{ME}	$0.75 \times MCR_{ME}$	kW	7447.5
5	P_{AE}	$0.05 \times MCR_{ME}$	kW	496.5
6	$C_{FPilotfuel}$	C_F factor of pilot fuel for dual fuel ME using MDO	-	3.206
7	$C_{FAEPilotfuel}$	C_F factor of pilot fuel for auxiliary engine using MDO	-	3.206
8	C_{FLNG}	C_F factor of dual fuel engine using LNG	-	2.75
9	$SFC_{MEPilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel ME at P_{ME}	g/kWh	6
10	$SFC_{AEPilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel AE at P_{AE}	g/kWh	7
11	$SFC_{ME\ LNG}$	Specific fuel consumption of ME using LNG at P_{ME}	g/kWh	136
12	$SFC_{AE\ LNG}$	Specific fuel consumption of AE using LNG at P_{AE}	g/kWh	160
13	V_{LNG}	LNG tank capacity on board	m^3	3100
14	V_{HFO}	Heavy fuel oil tank capacity on board	m^3	1200
15	V_{MDO}	Marine diesel oil tank capacity on board	m^3	400
16	ρ_{LNG}	Density of LNG	kg/m^3	450
17	ρ_{HFO}	Density of heavy fuel oil	kg/m^3	991
18	ρ_{MDO}	Density of marine diesel oil	kg/m^3	900

19	LCV_{LNG}	Low calorific value of LNG	kJ/kg	48000
20	LCV_{HFO}	Low calorific value of heavy fuel oil	kJ/kg	40200
21	LCV_{MDO}	Low calorific value of marine diesel oil	kJ/kg	42700
22	K_{LNG}	Filling rate of LNG tank	-	0.95
23	K_{HFO}	Filling rate of heavy fuel tank	-	0.98
24	K_{MDO}	Filling rate of marine diesel tank	-	0.98
25	f_{DFgas}	$\frac{P_{ME}+P_{AE}}{P_{ME}+P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$	-	0.5068
26	EEDI	$[P_{ME} \times (C_{F\ Pilotfuel} \times SFC_{ME\ Pilotfuel} + C_{F\ LNG} \times SFC_{ME\ LNG}) + P_{AE} \times (C_{F\ Pilotfuel} \times SFC_{AE\ Pilotfuel} + C_{F\ LNG} \times SFC_{AE\ LNG})] / (V_{ref} \times Capacity)$	gCO_2/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:



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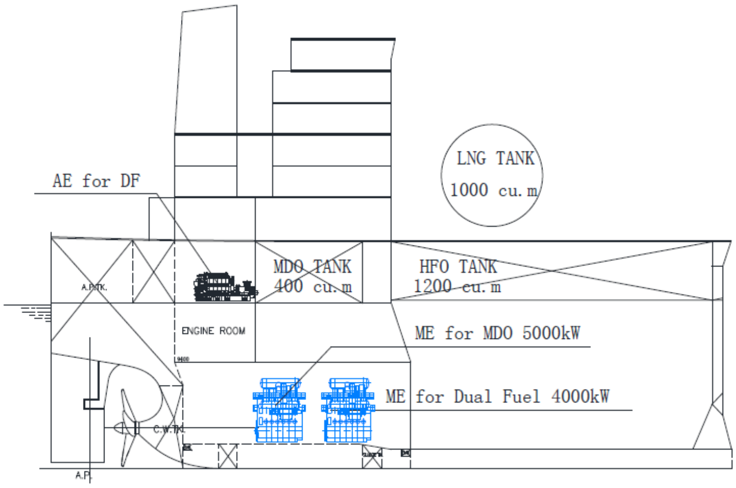
2	Capacity	Deadweight of the ship at summer load draft	DWT	81200
3	V_{ref}	Ships speed as defined in EEDI regulation	kn	14
4	P_{ME}	$0.75 \times MCR_{ME}$	kW	7447.5
5	P_{AE}	$0.05 \times MCR_{ME}$	kW	496.5
6	$C_{FPilotfuel}$	C_F factor of pilot fuel for dual fuel ME using MDO	-	3.206
7	$C_{FAEPilotfuel}$	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 Meat 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	$SFC_{ME\ MDO}$	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	ρ_{LNG}	Density of LNG	kg/m^3	450
20	ρ_{HFO}	Density of heavy fuel oil	kg/m^3	991
21	ρ_{MDO}	Density of marine diesel oil	kg/m^3	900
22	LCV_{LNG}	Low calorific value of LNG	kJ/kg	48000
23	LCV_{HFO}	Low calorific value of heavy fuel oil	kJ/kg	40200
24	LCV_{MDO}	Low calorific value of marine diesel oil	kJ/kg	42700
25	K_{LNG}	Filling rate of LNG tank	-	0.95
26	K_{HFO}	Filling rate of heavy fuel tank	-	0.98
27	K_{MDO}	Filling rate of marine diesel tank	-	0.98
28	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
29	$f_{DFliquid}$	$1-f_{DFgas}$	-	0.8739
30	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_2/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 as defined in EEDI regulation	kn	14
5	P_{MEMDO}	$0.75 \times MCR_{MEMDO}$	kW	3750
6	P_{AELNG}	$0.75 \times MCR_{MELNG}$	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	$C_{FAEPilotfuel}$	$C_F$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	$SFC_{AEPilotfuel}$	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^3	1000
18	V_{HFO}	Heavy fuel oil tank capacity on board	m^3	1200
19	V_{MDO}	Marine diesel oil tank capacity on board	m^3	400

20	ρ_{LNG}	Density of LNG	kg/m^3	450
21	ρ_{HFO}	Density of heavy fuel oil	kg/m^3	991
22	ρ_{MDO}	Density of marine diesel oil	kg/m^3	900
23	LCV_{LNG}	Low calorific value of LNG	kJ/kg	48000
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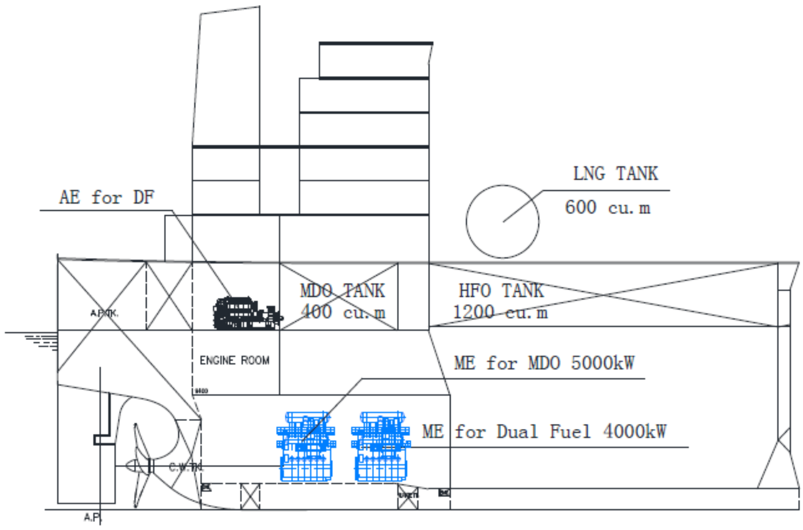
26	K_{LNG}	Filling rate of LNG tank	-	0.95
27	K_{HFO}	Filling rate of heavy fuel tank	-	0.98
28	K_{MDO}	Filling rate of marine diesel tank	-	0.98
29	f_{DFgas}	$\frac{P_{MEMDO}+P_{MELNG}+P_{AE}}{P_{MELNG}+P_{AE}} \times \frac{V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}{V_{HFO} \times \rho_{HFO} \times LCV_{HFO} \times K_{HFO} + V_{MDO} \times \rho_{MDO} \times LCV_{MDO} \times K_{MDO} + V_{LNG} \times \rho_{LNG} \times LCV_{LNG} \times K_{LNG}}$	-	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 as defined in EEDI regulation	kn	14
5	P_{MEMDO}	$0.75 \times MCR_{MEMDO}$	kW	3750
6	P_{AELNG}	$0.75 \times MCR_{MELNG}$	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	$C_{FAEPilotfuel}$	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	$SFC_{MEPilotfuel}$	Specific fuel consumption of pilot fuel for dual fuel ME at P_{ME}	g/kWh	6
13	$SFC_{AEPilotfuel}$	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	$SFC_{DF\ MDO}$	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^3	600
20	V_{HFO}	Heavy fuel oil tank capacity on board	m^3	1200
21	V_{MDO}	Marine diesel oil tank capacity on board	m^3	400
22	ρ_{LNG}	Density of LNG	kg/m^3	450
23	ρ_{HFO}	Density of heavy fuel oil	kg/m^3	991
24	ρ_{MDO}	Density of marine diesel oil	kg/m^3	900
25	LCV_{LNG}	Low calorific value of LNG	kJ/kg	48000
26	LCV_{HFO}	Low calorific value of heavy fuel oil	kJ/kg	40200
27	LCV_{MDO}	Low calorific value of marine diesel oil	kJ/kg	42700
28	K_{LNG}	Filling rate of LNG tank	-	0.95
29	K_{HFO}	Filling rate of heavy fuel oil	-	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	$[P_{MELNG} \times [\mathbf{f_{DFgas}} \times (C_{F\ Pilotfuel} \times SFC_{ME\ Pilotfuel} + C_{F\ LNG} \times SFC_{DF\ LNG}) + \mathbf{f_{DFliquid}} \times C_{FMDO} \times SFC_{DF\ MDO})] + P_{MEMDO} \times C_{F\ MDO} \times SFC_{ME\ MDO} + P_{AE} \times [\mathbf{f_{DFgas}} \times (C_{FAE\ Pilotfuel} \times SFC_{AE\ Pilotfuel} + C_{F\ LNG} \times SFC_{AE\ LNG}) + \mathbf{f_{DFliquid}} \times C_{FMDO} \times SFC_{AE\ MDO}]] / (V_{ref} \times Capacity)$	gCO_2/tnm	3.54