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SAFEMED III Seminar on MARPOL Annex VI

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GHG/Relevant Substances Efficiency & Emissions

Part IV - Energy Efficiency (EEDI/SEEMP)

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- **Energy Efficiency - GHG (...mainly CO_2)**
- **International Regulations and Guidance addressing GHG**

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International Regulations & Guidance addressing GHG - IMO

- **Revised MARPOL ANNEX VI - Resolution MEPC.203 (62), adopted in July 2011**
  - Inclusion of regulations on Energy Efficiency for Ships, CO_2
  - Related Guidelines on the EEDI/SEEMP, adopted in 2012:

Resolution MEPC.212 (63) - Method of Calculation of the Attained EEDI
Resolution MEPC.213 (63) - Development of SEEMP
Resolution MEPC.214 (63) - Survey and Certification of the EEDI
Resolution MEPC.215 (63) - Calculation of Reference Lines for the EEDI

- **MEPC.1/Circ.684, 2009** - Voluntary Guidelines for the EEOI

...and all the revisions/amendments adopted afterwards!

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What is the EEDI? Energy Efficiency Design Index (EEDI)

- The concept behind the EEDI is fairly simple and it is intended to represent ship CO_2 efficiency at a determined design point (Speed, Power, Draught, DWT)

$$EEDI = \frac{\text{Environmental impact}}{\text{Benefit to society}} = \frac{\text{Ship CO2 emissions}}{\text{Performed work}}$$

As so...

$$EEDI = \frac{CO_2 \text{ Main Engine} + CO_2 \text{ Auxiliary Engines}}{\text{Capacity} \times \text{Speed}}$$

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…and after some assumptions, calculations, corrections, conversions, etc., the EEDI is expressed in math terms as:

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

…a lower EEDI value means a more Energy-Efficient Ship Design!

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Several correction factors were included in the formula to account for:

- Ship specific design elements (e.g. ice-class, power redundancy)
- Decrease of speed in representative sea and weather conditions
- Innovative energy efficiency technologies
- Technical/regulatory limitation on capacity (e.g. voluntary structural enhancements, capacity correction factors)
- Cubic capacity correction factors (chemical tankers and gas carriers)

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- **EEDI** regulations agreed on Ship's coverage Type, Size, Required Reduction Targets (in%). Ships' coverage is around 70% against total CO_2 emissions.

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Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
Bulk carrier	20,000 DWT and above	0	10	20	30
	10,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Gas carrier	10,000 DWT and above	0	10	20	30
	2,000 – 10,000 DWT	n/a	0-10*	0-20*	0-30*
Tanker	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*
Container ship	15,000 DWT and above	0	10	20	30
	10,000 – 15,000 DWT	n/a	0-10*	0-20*	0-30*

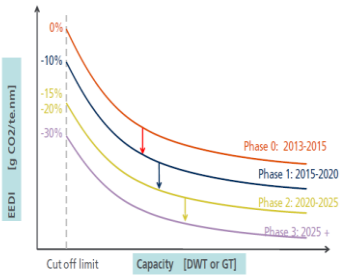
Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
General Cargo ships	15,000 DWT and above	0	10	15	30
	3,000 – 15,000 DWT	n/a	0-10*	0-15*	0-30*
Refrigerated cargo carrier	5,000 DWT and above	0	10	15	30
	3,000 – 5,000 DWT	n/a	0-10*	0-15*	0-30*
Combination carrier	20,000 DWT and above	0	10	20	30
	4,000 – 20,000 DWT	n/a	0-10*	0-20*	0-30*

* Reduction factor to be linearly interpolated between the two values dependent upon vessel size. The lower value of the reduction factor is to be applied to the smaller ship size.

n/a means that no required EEDI applies.

Ship type (as defined in MARPOL Annex VI Chapter 4, Regulation 2)	Reference line value = a × b^-c: a	b	c
Bulk carrier	961.79	DWT of the ship	0.477
Gas carrier	1120.00	DWT of the ship	0.456
Tanker	1218.80	DWT of the ship	0.488
Container ship	174.22	DWT of the ship	0.201
General cargo ship	107.48	DWT of the ship	0.216
Refrigerated cargo carrier	227.01	DWT of the ship	0.244
Combination carrier	1219.00	DWT of the ship	0.488
Passenger ship	Not initially subject to reference lines. Attained EEDI still needs to be calculated.		
Ro-ro cargo ship			
Ro-ro passenger ship			

Table 1: Parameters for determination of reference values for the different ship types (MARPOL Annex VI, Regulation 21)



Source: Lloyd's Register - December 2013

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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.XXX(63);

.6 no correction factors are used; and

.7 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 – see paragraph 15) is as follows:

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

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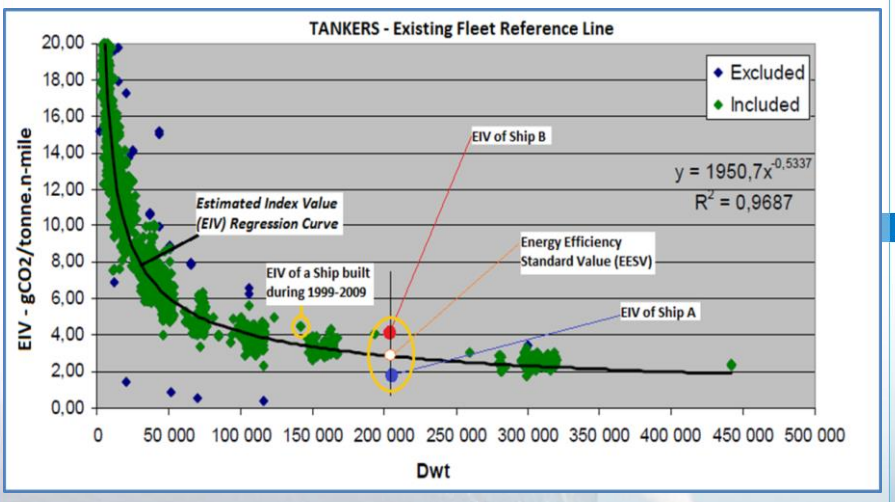

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- Several vessel types have been excluded (for the moment) from the draft regulations due to their specific trading and operation schemes, design criteria, lack of proper categorization, additional safe speed and power requirements, use of non-conventional propulsion…etc.

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Ship Type	Size	Phase 0 1 Jan 2013 – 31 Dec 2014	Phase 1 1 Jan 2015 – 31 Dec 2019	Phase 2 1 Jan 2020 – 31 Dec 2024	Phase 3 1 Jan 2025 and onwards
LNG carrier***	10,000 DWT and above	n/a	10**	20	30
Ro-ro cargo ship (vehicle carrier)***	10,000 DWT and above	n/a	5**	15	30
Ro-ro cargo ship***	2,000 DWT and above	n/a	5**	20	30
	1,000 – 2,000 DWT	n/a	0-5***	0-20*	0-30*
Ro-ro passenger ship***	1000 DWT and above	n/a	5**	20	30
	250 – 1,000 DWT	n/a	0-5***	0-20*	0-30*
Cruise passenger ship*** having non-conventional propulsion	85,000 GT and above	n/a	5**	20	30
	25,000 – 85,000 GT	n/a	0-5***	0-20*	0-30*

* Reduction factor to be linearly interpolated between the two values dependent upon vessel size. The lower value of the reduction factor is to be applied to the smaller ship size.
** Phase 1 commences for those ships on 1 September 2015.
*** Reduction factor applies to those ships constructed on or after 1 September 2015, as defined in paragraph 43 of regulation 2.

Note: n/a means that no required EEDI applies."

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International Regulations/Legislation

- **The Energy Efficiency Design Index (EEDI)**

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

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Design Data Needs - EEDI Technical File: Ships' particulars, type and relevant information for classification (inc. notations), main & auxiliary engines details, fuel type and its emission factor, reference speed, capacity, energy saving equipment, speed-power curves, electric power tables and the calculated values of both the attained EEDI and $EEDI_{weather}$

Note: Ships' power, speed, draught and capacity shall be consistent!

Availability - Ship Designers, Shipyards, Flag, Class, Manufacturers, etc.

Later, some of it will be available through Ships' commercial databases

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International Regulations & Guidance

- **The SEEMP - aiming to provide an EE Operational Profile**

It suggests the EEOI has an example to trying to represent ships' operational performance - single or average voyages

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{cargo,i} \times D_i)}$$

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Design Data Needs - Fuel Type and its Emission Factor (fuel mass to CO_2 mass conversion), Mass of consumed Fuel, Cargo carried (tonnes or gross tonnes) and Distance travelled corresponding to the cargo shifted or work done.

Also in SEEMP: Trim, ballast, speed optimisation, hull cleaning, weather routing, propeller, rudder and heading control, etc.

Availability - *Ships' side*: Owner/Operator/Manager/Charter, *Authorities side*: Ports and Maritime Authorities & Administrations, Flag State & PSC

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International Regulations & Guidance

Data is available through either Mandatory and Voluntary information

Fuel Type supplied and consumed

- Mandatory: Bunker Delivery Notes / Oil Record Book / Fuel Oil Sampling, kept on-board - *PSC survey and verification*

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- Voluntarily but recognised as normal practice among the shipping industry: On-board monitoring fuel oil consumption - Main & Auxiliary Engines, Oil-fired Boilers, IG Generators and Incinerators

Note: Verifying fuel oil quality testing according to International Standards e.g. **ISO 8217:2010** on Petroleum products - Fuels (class F) - Specifications of marine fuels

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International Regulations & Guidance

Data is available through either Mandatory and Voluntary information

Cargo Carried

- Mandatory (SOLAS & MARPOL): Cargo/Load Manifest, Cargo Record Book, kept on-board - *PSC survey and verification*
- Voluntarily: CDWT information obtained through Displacement *vs* Lightweight; draught measurements and stability documentation.

Distance travelled

- Mandatory (SOLAS): Navigation Log Book, Nautical Charts, ECDIS, Positioning Systems like AIS, LRIT, records on-board - *PSC survey and verification*

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THANK YOU FOR YOUR ATTENTION

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