GUIDELINES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 6. STATUTORY

VOLUME 5
GUIDELINES FOR DETERMINATION OF THE ENERGY EFFICIENCY DESIGN INDEX
2017 EDITION

BIRO KLASIFIKASI INDONESIA

GUIDELINES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 6. STATUTORY

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2017 EDITION

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Foreword

This Guidelines has prepared to determine the value of Energy Efficiency Design Index of ships that include of calculation and verification where addressed the attained EEDI only.

The EEDI verification is conducted in two stages. In the first, the preliminary EEDI-value which is determined based on basic design parameters and towing tank results or equivalent calculations. In the second stage the final EEDI-value is determined based on the parameters of the actual installed engine(s) and results of the sea trial on EEDI condition.

The scope of certification in this Guidelines is applied to new ships as defined in regulation 2.23 of MARPOL Annex VI of 400 gross tonnage and above.

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Table of Contents

Rules Amendment Notice

These pages contain amendments within the following Sections of the Guidelines for Determination of the Energy Efficiency Design Index, 2017 Edition.

These amendments are effective from 1th July 2017

Paragraph	Title/subject	Status/Remark
Section 1 - General Information		
A	**General**	
1	Scope and application	To add the new scope of applications and references according to the IMO Regulations.
B	**Definitions**	
1	EEDI Technical File	To add new provision for language used in the EEDI Technical file
2	Attained EEDI	To add new provision for parameters attached to the EEDI Technical file
C	**Terms and Abbreviations**	
D	**Reference Documents**	
	No Tittle	To add new references
Section 2- Energy Efficiency Design Index (EEDI) Certificate		
A	**General**	
	No Tittle	To add new provisions regarding the reference update of ITTC Recommended Procedure and ISO standards
B	**Required Information and Documents2-2**	
2 & 4	No Tittle	To add new provisions regarding the reference update of ITTC Recommended Procedure and ISO standards
5	No Tittle	To add new provisions for the verification of the attained EEDI in case of major conversion
C	**EEDI Calculation Procedure**	
	No Tittle	To add new provisions of the calculation procedures for the additional ship types as amended in the Section 1.A.1.Scope of Application.

Section 1

General Information

A. General

1. Scope and application

1.1 These Guidelines consist of procedure of EEDI calculation, survey and certification where addressed the attained EEDI only. For this purpose BKI will be act as a verifier for the EEDI as described by the IMO Guidelines.

1.2 The EEDI Certification confirms a ship's design energy efficiency comprising verification of the design CO_2 emissions, capacity and corresponding reference speed according to MEPC.212(63), 214(63) and IACS PR 38 Rev.1.

1.3 The scope of certification in this Guidelines apply to new ships as defined in regulations 2.23 MARPOL Annex VI of 400 gross tonnage and above of the ship types defined in regulations 2.25 to 2.31, 2.33 to 2.35, 2.38 and 2.39, as follow:

- Bulk carriers,
- Tankers
- Gas carriers,
- LNG carrier ((contracted on or after 1 September 2015),
- Cruise passenger ship having non-conventional propulsion (contracted on or after 1
- September 2015)
- Container ships,
- General cargo ships,
- Ro-ro cargo ship (vehicle carrier) (contracted on or after 1 September 2015)
- Ro-ro cargo ship (contracted on or after 1 September 2015)
- Ro-ro passenger ship (contracted on or after 1 September 2015)
- Refrigerated cargo ships
- Combination carriers.

1.4 The calculation and verification of EEDI are to be performed for each:

- new ship before ship delivery consist of preliminary verification at the design stage and final verification at the sea trial.
- new ship in service which has undergone a major conversion
- new or existing ship which has undergone a major conversion that is so extensive that the ship is regarded by the Administration as a newly constructed ship

1.5 These Guidelines shall not apply to ships which have non-conventional propulsion, such as diesel-electric propulsion, turbine propulsion or hybrid propulsion systems, with the exception of cruise passenger ships with diesel-electric propulsion and LNG carriers having diesel-electric or steam turbine propulsion systems.
These Guidelines shall not apply to cargo ships having ice-breaking capability as defined in regulation 2.42 of MARPOL Annex VI As a consequence, the Industry Guidelines apply to cargo vessels with ice class up to and including Finnish-Swedish ice class 1A Super or equivalent unless they qualify as a ship with ice-breaking capability in which case they are exempt. The intermediate Polar Classes, namely PC4 and PC5, need to demonstrate icebreaking capability through ice trials to qualify. In the initial stages, ice-breaking capability can be demonstrated based on ice tank tests.

2. Certificate

2.1 The EEDI is one of IMO's instruments to reduce greenhouse gas emissions emitted by the shipping industry. The purpose of the EEDI is to reduce CO_2 emissions from future new buildings. The EEDI enables a comparison of the energy efficiency between ships of the same type and similar size.

2.2 For ships with BKI Class Notation EP+, the EEDI Certificate will become a part of the Environmental Passport (EP) certificate documentation.

2.3 The certificate is valid for the lifetime of the ship. Following major conversions, or changes in essential equipment (which would change the value of the attained EEDI), a reassessment of the EEDI becomes necessary and a new certificate will need to be issued.

B. Definitions

1. EEDI Technical File

The EEDI Technical File is the basic document for the EEDI certification and includes all EEDI relevant data and information. The EEDI Technical File should be written at in least in English. A sample EEDI Technical File is attached in Annex A.

2. Attained EEDI

The attained EEDI is the actual calculated and verified EEDI value for an individual ship based on the data in the EEDI Technical File, minimum should contain each value of the calculation parameters and the calculation process. In the following EEDI-value is used synonymously for attained EEDI.

3. Capacity

Depending on the ship type, different units for capacity will be used:

- For bulk carriers, tankers, gas carriers, container ships, general cargo ships, refrigerated cargo ships and combination carriers deadweight (DWT) should be used.
- For container ships capacity is to set to 70 % of DWT.

4. The deadweight is the difference between displacement and lightweight of ship at summer load draft.

5. EEDI conditions, referring to line of a model ship and full scale ship, define the EEDI draft, power and corresponding speed. The lines of a model ship include sheer plan, body plan and half-breadth plan.

6. Applicant

The applicant is the party who applies for the EEDI certificate.

7. Towing tank test

Means model towing tests, model self-propulsion tests and model propeller open water tests. Numerical calculations may be accepted as equivalent to model propeller open water tests or used to complement the tank tests conducted (e.g. to evaluate the effect of additional hull features such as fins, etc., on ship's performance), with approval of the verifier.

8. Major conversion

"Major Conversion" means in relation to chapter 4 a conversion of a ship:

- which substantially alters the dimensions, carrying capacity or engine power of the ship; or
- which changes the type of the ship; or
- the intent of which in the opinion of the Administration is substantially to prolong the life of the ship; or
- which otherwise so alters the ship that, if it were a new ship, it would become subject to relevant provisions of the present Convention not applicable to it as an existing ship; or
- which substantially alters the energy efficiency of the ship and includes any modifications that could cause the ship to exceed the applicable required EEDI as set out in regulation 21.

C. Terms and Abbreviations

Table 1.1 Abbreviations

EEDI	Energy Efficiency Design Index
EIAPP	Engine International Air Pollution Prevention
IEC	International Electrotechnical Commission
ITTC	International Towing Tank Conference
MCR	Maximum Continuous Rating
MEPC	Marine Environmental Protection Committee
ISO	International Standard Organization
CFD	Computational Fluid Dynamic

D. Reference Documents

1. IACS PR.38 Rev.1, Procedure for calculation and verification of the Energy Efficiency Design Index (EEDI), 2016.

2. IMO MEPC.212(63), Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships 2012 as amended by MEPC.263(68) and MEPC.281(70), 2015.

3. IMO MEPC.214(63), Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI) 2012 as amended by MEPC.234(65) and MEPC.254(67), 2014.

4. ISO 15016, "Ships and marine technology -Guidelines for the assessment of speed and power performance by analysis of speed trial data", 2015

5. ISO 19019, "Sea-going vessels and marine technology - Instruction for planning, carrying out and reporting sea trial", 2005

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Section 2

Energy Efficiency Design Index (EEDI) Certificate

A. General

1. Objective

1.1 These Guidelines describe the verification process of the EEDI and the issuing of an EEDI certificate. They further list the documentation which shall be submitted to BKI.

2. Scope

2.1 The purpose of these Guidelines is to describe the level of documentation and the procedure to verify the EEDI key input parameters for these following sea trials.

2.2 Survey and certification of the EEDI are to be conducted on two stages; preliminary verification at the design stage and final verification at the sea trial.

2.3 A preliminary examination is performed at the design stage after towing tank tests, or equivalent, have been performed, to document the EEDI-value for the planned ship.

2.4 The final verification is performed after the sea trials when the reference speed under EEDI has been determined.

3. Verification process

3.1 The EEDI verification is conducted in two stages. In the first, stage the preliminary EEDI-value is determined based on basic design parameters and towing tank results or equivalent calculations. In the second stage the final EEDI-value is determined based on the parameters of the actual installed engine(s) and results of the sea trial on EEDI condition. An overview of the verification process is given in Fig. 2.1.

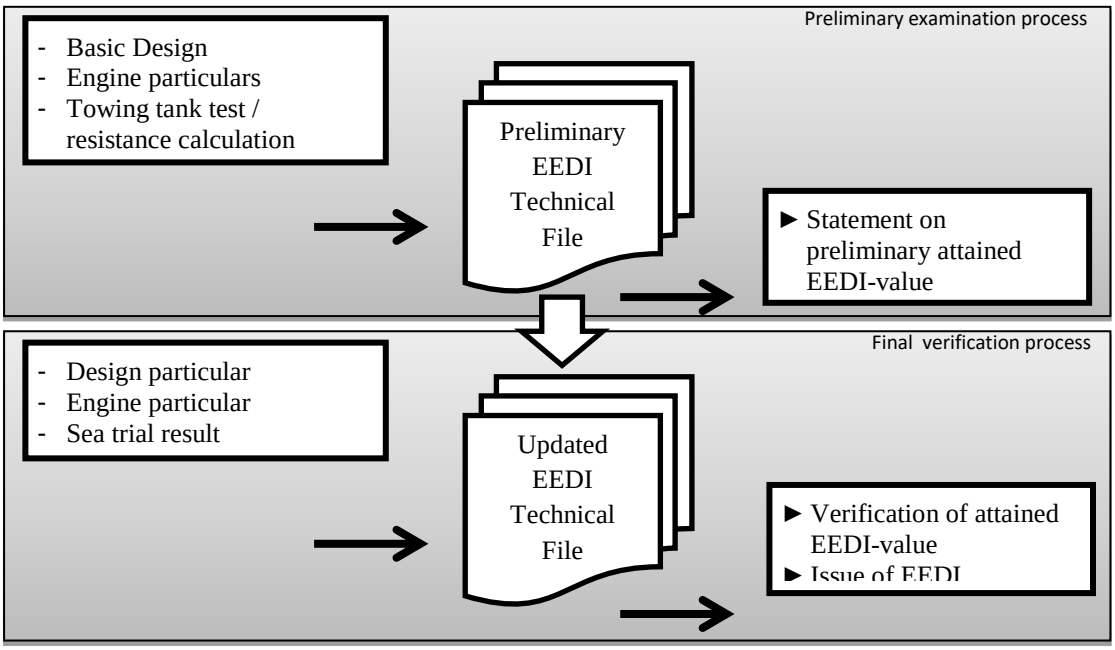

Fig. 2.1 EEDI verification process

B. Required Information and Documents

1. Documents to be submitted

Table 2.1 Documents to be submitted for preliminary examination

1.	Preliminary EEDI Technical File
2.	EIAPP certificate and NOx Technical File for main and auxiliary engines, if not available manufacturers' documentation for engine, specific fuel oil consumption and fuel oil type used.
3.	Loading manual / preliminary trim and stability booklet, alternatively a freeboard calculation
4.	Ship lines and model particulars (Report including the particulars of the ship model and propeller model)
5.	Power-speed curves predicted at full scale in sea trial condition and EEDI condition
6.	Electric Power Table If P_{AE} is significantly different from the values computed using the formula in Table 2.2 P_{AE} of these guidelines.
7.	Description of the towing tank test facility and towing tank test organization quality manual
8.	If gas fuel is used as the primary fuel of the ship fitted with dual fuel engines. Gas fuel storage tanks (with capacities) and bunkering facilities are to be described.
9.	Ship reference speed V_{ref} Detailed calculation process of the ship speed, which is to include the estimation basis of experience-based parameters such as roughness coefficient, wake scaling coefficient
10.	If applied in the EEDI calculation manufactures' documentation of innovative technologies
11.	Model test results
12.	Additional information
13.	Deadweight (DWT) or gross tonnage (GT) for passenger and ro-ro passenger ships.

2. EEDI Technical File

2.1 The EEDI Technical File shall include all EEDI relevant information. The information shall be clear and free of interpretation including a comprehensible EEDI calculation. A template for an EEDI Technical File is given in the Annex A.

3. Preliminary examination

3.1 A preliminary EEDI Technical File is to be submitted to BKI for the preliminary examination of the EEDI-value. The information in the Technical File is the basis for the EEDI calculation. The Technical File shall include the principal particulars of the vessel and all items shown in Table 2.2. The calculation of the EEDI will be carried out according to C, EEDI Calculation Procedure.

3.2 Additional information shall be submitted to BKI by the applicant. Additional information is not included in the EEDI Technical File, but is needed for the verification. Additional information will be returned to the applicant following the final verification to safeguard intellectual property rights. The requested items of the additional information are summarized in Table 2.3.

3.3 The determination of the speed-power curves for ballast and EEDI condition shall be achieved by the same method and procedure.

3.4 Towing tank test will be accepted if it is documented that the model's lines correspond with the lines of the full scale ship.

3.5 Towing tank test of sister vessels will be accepted if it is documented that the ships are of same design.

Table 2.2 Data for preliminary EEDI Technical File

Parameter	Description	Unit
C_F	The conversion factor of the fuel type used for EIAPP certification in NO_x Technical File of all main and auxiliary engines as defined in MEPC.212(63).	g CO_2/g fuel
Δ	The displacement should be taken from the loading manual / preliminary trim and stability booklet.	t
DWT	The deadweight should be taken from the loading manual / preliminary trim and stability booklet, alternatively a freeboard calculation.	t
L_{PP}	96 percent of total length on waterline at 85 per cent 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 water line.	m
$f_{eff(i)}$	The availability factor for each innovative energy efficiency technology shall be based on comprehensive documentation of the determination for each innovative energy efficiency technology For waste heat recovery systems $f_{eff(i)}$ shall be set to one.	
f_i	Capacity correction factor for any technical/regulatory limitation on capacity. For ice-classed ships, f_i is determined by the standard given in MEPC.212(63), Table 2: "Capacity correction factor f_i for ice-classed ships" Documentation on intended ice class	
f_j	Correction factor to account for ship specific design elements. For ships with planned ice class f_j is given in MEPC.212(63), Table 1: "Correction factor for power f_j for ice-classed ships" Documentation on intended ice class	
f_W	Is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed as determined in 2.9 of MEPC.212 (63)	
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. The formula for determined of f_c is specified in 2.12 of MEPC.212(63).	
GT	GT shall be calculated acc. to the International Convention of Tonnage Measurements of ships 1969, corresponding documentation shall be submitted	
Lightweight (LWT)	The lightweight shall be taken from the loading manual / preliminary trim and stability booklet.	t
P_{AE}	– If $MCR_{ME(i)} > 10{,}000$ kW, P_{AE} shall be calculated as: $P_{AE} = \left(0.025 \times \left(\sum_{i=1}^{nME} MCR_{MEi} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75}\right)\right) + 250$ – If $P_{ME(i)} < 10{,}000$ kW, P_{AE} shall be: $P_{AE} = \left(0.05 \times \left(\sum_{i=1}^{nME} MCR_{MEi} + \frac{\sum_{i=1}^{nPTI} P_{PTI(i)}}{0.75}\right)\right)$	kW
$P_{Aeff(i)}$	Manufacturer's documentation acc. to existing IEC and ISO standards incl. factory acceptance test data for auxiliary power reduction with innovative mechanical energy efficient technology.	kW
$P_{eff(i)}$	Manufacturer's documentation acc. to existing IEC and ISO standards incl. factory acceptance test data for power output of each innovative mechanical energy efficient technology.	kW
$P_{ME(i)}$	EIAPP certificate to document MCR of main engine(s). Manufacturer's documentation is required if an EIAPP certificate is not available at the design stage.	kW
$P_{PTI(i)}$	Manufacturer's documentation acc. to existing IEC and ISO standards incl. factory acceptance test data for power take-in devices (e.g. shaft motor). If a shaft motor is installed also the weighted average efficiency of the generators shall be documented	kW

Table 2.2 Data for preliminary EEDI Technical File continued

Parameter	Description	Unit
$P_{PTO(i)}$	Manufacturer's documentation acc. to existing IEC and ISO standards incl. factory acceptance test data for power take-off devices (e.g. shaft generator) and their efficiency. Alternatively a fixed value of 0.9 could be used as efficiency.	kW
SFC_{AE}	EIAPP certificate and NO_x Technical File acc. NO_x Technical Code to document specific fuel oil consumption at 50% of MCR power of auxiliary engine(s). Manufacturer's documentation is required if an EIAPP certificate is not available at the design stage. If no EIAPP Certificate for an engine is available because its power is below 130 kW, the SFC specified by the manufacturer and endorsed by a competent authority should be used	g/kWh
$SFC_{ME(i)}$	EIAPP certificate and Technical File acc. NO_x Technical Code to document specific fuel oil consumption at 75% of MCR power of main engine(s) Manufacturer's documentation is required if an EIAPP certificate is not available at the design stage.	g/kWh
v_{ref}	A speed-power curve from towing tank test (or equivalent) for a) EEDI conditions, and b) Ballast conditions at sea trial The documents shall include the name and particulars of the towing tank facility where the towing tank tests were conducted and the details of the calculation method.	kn

Table 2.3 Additional information and documentation for preliminary examination

Items	Required documents and description
Description of the towing tank facility	The documentation shall include name and location of the facility, the particulars of the tank and used equipment, and the calibration records of the measuring equipment used.
Lines of the model ship and the actual ship	Sheer plan, body plan and half-breadth plan should be as detailed as to demonstrate the similarity between the model ship used for the tank test and the actual ship.
Detailed report on tank tests	The documentation shall include the description of the test procedure, uncorrected measured data of the tank tests, shipbuilder's experience-based parameters, and propeller open water characteristics. Preferably the tank test shall be conducted acc. to ITTC Recommended Procedure 7.5-04-01-01.12 1; 2014 or ISO 15016:2015
Report of the calculation of the power curves	Detailed documentation of the calculation process.
reasons for exempting a tank test, if applicable	this should include lines and tank test results of the ships of same type, and the comparison of the principal particulars of such ships and the ship in question. Appropriate technical justification should be provided explaining why the tank test is unnecessary

4. Final verification

4.1 Prior to the sea trial, the following documents should be submitted to the verifier: a description of the test procedure to be used for the speed trial, the final displacement table and the measured lightweight, or a copy of the survey report of deadweight, as well as a copy of NO_x Technical File as necessary. The test procedure should include, at a minimum, descriptions of all necessary items to be measured and corresponding measurement methods to be used for developing power curves under the sea trial condition.

4.2 The final verification of the EEDI will be conducted subsequently to the sea trial of the ship. The EEDI Technical File shall be updated by the results of the sea trial and data of the built ship.

4.3 The final EEDI Technical File shall be submitted to BKI. The documentation for the final EEDI verification shall include all items of Table 2.4. The final EEDI Technical File shall include all data specified in Table 2.5.

4.4 Additional information of the sea trial is necessary for a comprehensive EEDI verification. Additional information will be returned to the shipbuilder following the final verification. The additional information is summarized in Table 2.6.

4.5 If all parameters are submitted and verified the EEDI will be calculated and an EEDI certificate will be issued.

Table 2.4 Documentation to be submitted

1. Final EEDI Technical File
2. EIAPP certificate and NO_x Technical File for main and auxiliary engines
3. International Tonnage Certificate
4. Results of inclining test / Lightweight survey documentation
5. Documentation of measured main and auxiliary power reduction with innovative mechanical energy efficient technology and method used
6. Documentation of reference speed calculation

Table 2.5 Data for final EEDI Technical File

Parameter	Description	Unit
CF	The conversion factor of the fuel type used for EIAPP certification in NO_x Technical File of all main and auxiliary engines as defined in MEPC.212(63)	g CO_2 / g fuel
Δ	Displacement tables as given in the final stability booklet or from the results of the inclining test	t
DWT	The deadweight of summer load draft as outlined in the final stability booklet.	t
$f_{eff(i)}$	If applicable, documentation on measured availability for each innovative energy efficiency technology and method used	
f_i	Correction factor to account for ship specific design elements which reduce the capacity.	
f_j	Correction factor to account for ship specific design elements,	
f_W	Not applicable. This coefficient shall be set to one, until guidelines are issued by IMO.	
GT	International Tonnage Certificate	
Lightweight (LWT)	Derived lightweight determined in inclining test. Alternatively, a lightweight survey documentation	t
P_{AE}	Only if the P_{AE} value calculated by the standard method is significantly different from the total power used at normal seagoing, documentation of consumed electric power (excluding propulsion) in EEDI condition at reference speed (v_{ref}), according to guidelines.	kW
$P_{Aeff(i)}$	Documentation of measured auxiliary power reduction with innovative mechanical energy efficient technology and method used	kW
$P_{eff(i)}$	Documentation of measured power of each innovative mechanical energy efficient technology and method used	kW
$P_{ME(i)}$	EIAPP certificate for the main engine(s) Documentation of measured shaft power and method used at sea trial, and the calibration records of the measuring equipment used	kW

Table 2.5 Data for final EEDI Technical File continued

Parameter	Description	Unit
$P_{PTI(i)}$	Documentation of measured power taken-in and method used Manufacturer's documentation on efficiency of the installed generators	kW
$P_{PTO(i)}$	Documentation of measured power taken-off and method used Manufacturer's documentation on efficiency	kW
SFC_{AE}	− EIAPP certificate for the main engine(s) and the technical file acc. NO_x Technical Code − If no NO_x Technical File for an engine is available because its power is below 130 kW, the SFC specified by the manufacturer and endorsed by a competent authority should be used	g/kWh
$SFC_{ME(i)}$	EIAPP certificate for the main engine(s) and the technical file acc. NO_x Technical Code.	g/kWh
v_{ref}	Measured speed acc. ISO 15016:2015 or ITTC Recommended Procedure 7.5-04-01-01.1at sea trials for EEDI condition or for ballast draft corresponding to the towing tank tests (or equivalent), speed calculation, documentation of the calculation procedure used to determine v_{ref}. Documentation of sea trial with measurement protocol incl. list of measurement equipment, measuring method, and speed-power curves.	Kn

Table 2.6 Additional information and documentation for final verification

Item	Documentation and description
Report of the sea trial	Documentation shall include description of measuring and sea trial procedure observed and measured environmental conditions, draft and trim of the ship, uncorrected measured data, and the calibration records of the measuring equipment used. The sea trial report shall include the speed-power curves.

4.6 Sea conditions and ship speed should be measured in accordance with ITTC Recommended Procedure 7.5-04-01-01.12 Part 1; 2014 or ISO 15016:2015. If it is physically impossible to meet the conditions in the ISO15016:2015 or ITTC Recommended Procedure 7.5-04-01-01, a practical treatment shall be allowed based on the documented mutual agreement among the owner, the verifier and the shipbuilder.

4.7 The shipyard and verifier should compare the power curves obtained as a result of the sea trial and the estimated power curves at the design stage. In case differences are observed, the attained EEDI should be recalculated, as necessary, in accordance with the following:

4.7.1 For ships for which sea trial is conducted under the condition as specified in Table 2.5 (v_{ref}) : the attained EEDI should be recalculated using the measured ship speed at sea trial at the power of the main engine as specified in C.2.1(P_{ME}); and

4.7.2 For ships for which sea trial cannot be conducted under the condition as specified in Table 2.5 (v_{ref}): if the measured ship speed at the power of the main engine as specified in C.2.1(P_{ME}) at the sea trial conditions is different from the expected ship speed on the power curve at the corresponding condition, the shipbuilder should recalculate the attained EEDI by adjusting ship speed under the condition as specified in Table 2.5 (v_{ref}) by an appropriate correction method that is agreed by the verifier.

4.8 In cases where the finally determined deadweight/gross tonnage differs from the designed deadweight/gross tonnage used in the EEDI calculation during the preliminary verification, the Shipyard should recalculate the attained EEDI using the finally determined deadweight/gross tonnage. The finally determined gross tonnage should be confirmed in the Tonnage Certificate of the ship.

4.9 In case where the attained EEDI is calculated at the preliminary verification by using *SFC* based on the manufacturer's test report due to the non-availability at that time of the approved NO_x Technical File, the EEDI should be recalculated by using *SFC* in the approved NO_x Technical File.

4.10 The EEDI Technical File should be revised, as necessary, by taking into account the results of sea trial. Such revision should include, as applicable, the adjusted power curve based on the results of sea trial (namely, modified ship speed under the condition as specified in Table 2.5 (v_{ref})), the finally determined deadweight/gross tonnage and *SFC* described in the approved NO_x Technical File, and the recalculated attained EEDI based on these modifications.

4.11 The EEDI Technical File, if revised, should be submitted to the verifier for the confirmation that the (revised) attained EEDI is calculated in accordance with regulation 20 of MARPOL Annex VI and these Guidelines.

5. Verification of the attained EEDI in case of major conversion

5.1 A major conversion is defined as in MARPOL Annex VI regulation 2.24 and interpretations in MEPC.1/Circ.795/Rev2, subject to the approval of the Administration.

5.2 In cases where a major conversion is made to a ship, the ship owner should submit to a verifier an application for an Additional Survey with the EEDI Technical File duly revised based on the conversion made and other relevant background documents.

5.3 The background documents should include at least but are not limited to:

- documents explaining details of the conversion;
- EEDI parameters changed after the conversion and the technical justifications for each respective parameter;
- reasons for other changes made in the EEDI Technical File, if any; and
- calculated value of the attained EEDI with the calculation summary, which should contain, at a minimum, each value of the calculation parameters and the calculation process used to determine the attained EEDI after the conversion.

5.4 For verification of the attained EEDI after a conversion, speed trials of the ship are required, as necessary. No speed trials are necessary if the conversion or modifications don't involve a variation in reference speed.

5.5 The verifier should review the revised EEDI Technical File and other documents submitted and verify the calculation process of the attained EEDI to ensure that it is technically sound and reasonable and follows regulation 20 of MARPOL Annex VI and the these Guidelines. If the review leads to the conclusion that the modifications couldn't cause the ship to exceed the applicable required EEDI, the verifier will not request speed trials.

5.6 If such conclusion cannot be reached, like in the case of a lengthening of the ship, or increase of propulsion power of 10% or more, speed trials will be required.

5.7 If an Owner voluntarily requests re-certification of EEDI with IEE Certificate reissuance on the basis of an improvement to the ship efficiency, the verifier may request speed trials in order to validate the attained EEDI value improvement.

5.8 If speed trials are performed after conversion or modifications changing the attained EEDI value, tank tests verification is to be requested if the speed trials conditions differ from the EEDI condition. In this case, numerical calculations performed in accordance with defined quality and technical standards (ITTC 7.5-03-01-04 at its latest revision or equivalent) replacing tank tests may be accepted by the verifier to quantify influence of the hull modifications.

5.9 In case of major conversion of a ship without prior EEDI, EEDI computation is not required, except if the Administration considers that due to the extensive character of the conversion, the ship is to be considered as a new one.

C. EEDI Calculation Procedure

1. Scope

1.1 The following gives advice how to calculate the attained EEDI and which terms of the EEDI formula are to applied.

1.2 The EEDI formula consists of four terms which address different ship design criteria. In the following these terms are explained and advice is given when they should be applied.

Main engine(s) CO_2 emissions

$$EEDI_{attained} = \left\{ \left(\prod_{j=1}^{n} f_j \right) \left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)} \right) \right.$$

Auxiliary engine(s) CO_2 emissions

$$+ (P_{AE} \cdot C_{FAE} \cdot SFC_{AE}) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)} \right) C_{FAE} \cdot SFC_{AE} \right)$$

CO_2 emission reduction due to Innovative technology(s)

$$\left. - \left(\sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME} \right) \right\} \cdot \underbrace{\frac{1}{f_i \; Cf_c \; CCapacity \cdot V_{ref} \; eff_w}}_{\text{Transport work}}$$

2. Procedure

2.1 Determination of main engine(s) CO_2 emissions

2.1.1 The CO_2 emissions for all installed main engines shall be calculated as follows:

$$\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)}\, MESFC_{ME(i)}\right)$$

Where:

C_{FME} is the conversion factor fuel oil to CO_2 and depends on the fuel type documented in the NO_x Technical File.

Some examples are given in the table below:

Type of fuel	CF [t-CO_2/ t-Fuel]	Reference
Diesel/Gas Oil	3.206000	ISO 8217
Light Fuel Oil (LFO)	3.151040	ISO 8217
Heavy Fuel Oil (HFO)	3.114400	ISO 8217
Liquefied Petroleum Gas (LPG)	3.000000 3.030000	Propane Butane
Liquefied Natural Gas (LNG)	2.750000	

SFC_{ME} is the specific fuel oil consumption of the main engine at 75 % MCR acc.to NO_x Technical File.

Gas fuel may be used as primary fuel for one or more of the main and auxiliary engine(s) in accordance with paragraph 4.2.3 of the IMO Verification Guidelines.

For these dual-fuel engines, the CF factor and the Specific Fuel Consumption for gas (LNG) and for pilot fuel should be combined at the relevant EEDI load point as described in 2.5.1 and Appendix 4 of the IMO Calculation Guidelines

For LNG carriers with steam turbine propulsion, The Specific Fuel Consumption of the steam turbine should be determined during the running tests of the main boilers and steam turbines on board under load during the sea trials. For preliminary estimate of EEDI, manufacturer's certificate is to be used.

P_{ME} is 75 % of MCR_i of the main engine, if a shaft generator is installed, MCR of the main engine can be reduced by P_{PTOi}. P_{PTOi} is 75 % of the mechanical rated power of the shaft generator divided by the relevant efficiency of the shaft generator.

$P_{ME(i)} = 75\ \% (MCR_{(i)} - P_{PTO})$

$$\text{With } P_{PTO} = 75\ \% \left(\frac{\text{Output shaft generator}}{\eta_{SG}}\right)$$

ΣPME may be 0(zero) if the ship is a diesel-electric cruise passenger ship.

For LNG carriers having diesel electric propulsion system, the power PME is 83% of the rated output of the electrical propulsion motor(s) divided by the electrical chain efficiency from the output of the auxiliary engines to the output of the propulsion motor(s).

For LNG carriers having steam turbine propulsion system, the power PME is 83% of the rated installed power of steam turbines.

i represents each installed main engine

f_j is the correction factor to account for ship specific design elements, if no ship specific design elements are installed the factor is set to 1

For Finnish-Swedish ice class notations or equivalent notations of the Classification Societies, the fj correction factor is indicated in Table 1 under 2.8.1 of the IMO Calculation Guidelines.

For shuttle tankers with propulsion redundancy defined as oil tankers between 80,000 and 160,000 deadweight equipped with dual-engines and twin-propellers and assigned the class notations covering dynamic positioning and propulsion redundancy, the fj factor is 0.77.

The total shaft propulsion power of shuttle tankers with redundancy is usually not limited by verified technical means.

For ro-ro cargo and ro-ro passenger ships, the factor fjRoRo is to be computed according to 2.8.3 of the IMO calculation Guidelines.

For general cargo ships, the factor fj is to be computed according to 2.8.4 of the IMO Calculation Guidelines.

fj factors for ice-class and for ship's type can be cumulated (multiplied) for ice-classed general cargo ships or ro-ro cargo or ro-ro passenger ships.

n_{ME} is the number of installed main engines

η_{SG} efficiency of the shaft generator, if no specific manufacturer information is available, η_{SG} should be set to 0.7

Output shaft generator: rated output power in kW of the shaft generator

2.2 Determination of auxiliary engine(s) CO_2 emissions

2.2.1 The auxiliary engine power and its corresponding CO_2-emissions are calculated as follows:

$$C_{FAE} \cdot SFC_{AE} \cdot P_{AE}$$

Where:

C_{FAE} is the conversion factor fuel oil to CO_2 and analogous to use as describe for the main engine. If engines with different fuel types are installed CF should be the weighted average of the conversion factors of the different engines.

$$C_f = \frac{\sum_{i=1}^{n_{AE}} C_{FAE(i)} \cdot MCR_{AE(i)}}{\sum_{i=1}^{n_{AE}} MCR_{AE(i)}}$$

is the specific fuel oil consumption of the main engine at 50 % MCR acc. to NO_x Technical File

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

$$SFC_{AE} = \frac{\sum_{i=1}^{n_{AE}} SFC_{AE(i)} \cdot MCR_{AE(i)}}{\sum_{i=1}^{n_{AE}} MCR_{AE(i)}}$$

MCR_{AE} is the maximum continuous rating of each (i) auxiliary engine acc. to its EIAPP certificate
n_{AE} is the total number of auxiliary engines installed on board.

Note
If part of the PAE is provided by shaft generators, SFC_{ME} may – for that part of the power – be used instead of SFC_{AE}, i.e.:

If $P_{PTO} \geq P_{AE}$:
$CF_{AE} . SFC_{ME} . P_{AE}$,

If $P_{PTO} \leq P_{AE}$:
$CF_{ME} \neg . SFC_{ME} . PP_{TO} + CF_{AE} . SFC_{AE} . (P_{AE} – P_{PTO})$

P_{AE} is the considered auxiliary power demanded for the operation of the main engine(s) and calculated as a share of the installed main engine power

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

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

2.2.2 Shaft motors, innovative electrical energy efficient technology and design restrictions due to ice class are calculated as follows:

$$\left(\prod_{j=1}^{M} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum f_{eff(i)} . P_{AEeff(i)}\right) C_{FAE} . SFC_{AE}$$

Where:
f_j is the correction factor to account for ship specific design elements, if no ship specific design elements are installed the factor is set to 1

P_{PTI} is 75 % of the rated mechanical power of the shaft motor(s) divided by the weighted efficiency of the generators

$$P_{PTI(i)} = 0.75\ \frac{\text{rated power shaft motor (i)}}{\eta_{Gen}}$$

$$\eta_{Gen} = \frac{\sum_{i=1}^{nAE} \eta_{Gen(i).}\ \text{Output capacity}_{Gen(i)}}{\sum_{i=1}^{nAE} \text{Output capacity}_{Gen(i)}}$$

f_{eff} is the availability factor for each innovative technology. The availability factor should be calculated acc. to IMO guidelines. As long as these are not finished the calculation of the availability factor should be agreed with GL. For waste heat recovery systems feff should be set equal to 1.

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

2.3 Determination of the CO_2 emission reduction due to innovative technologies

2.3.1 If technologies are installed which reduce the main engine power the following term can be applied:

$$\sum_{i=1}^{n_{eff}} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}$$

Where:

f_{eff} is the availability factor for each innovative technology. The availability factor should be calculated acc. to IMO guidelines. As long as these are not finished the calculation of the availability factor should be agreed with BKI. For waste heat recovery systems f_{eff} should be set equal to 1.

P_{eff} is 75 % of the main engine power reduction due to mechanical energy efficiency technologies. The determination of P_{eff} should be documented comprehensively and be submitted to BKI. For wind propulsion systems as innovative technology f_{eff} and P_{eff} should be calculated acc. to MEPC 62/5/12.

C_{FME} is the conversion factor, as described in 2.1.1

SFC_{ME} is the specific fuel oil consumption, as described in 2.1.1

2.3.2 Energy efficiency technologies which reduce the main engine power mean, for example, additional sail or kite propulsion systems, or Flettner rotor systems.

2.4 Calculation of the transport work

2.4.1 The transport work is estimated by multiplying the ship capacity as defined under 2.3 of the IMO Calculation Guidelines by the ship's reference speed corresponding draft. The reference speed is determined at 75% of the rated installed power in general and 83% of the rated installed propulsion power for LNG carriers having diesel electric or steam turbine propulsion systems.

2.4.2 The transport work is calculated as follows:

$$f_i \cdot f_c \cdot \text{Capacity} \cdot v_{ref} \cdot f_w$$

Where:

f_i is a correction factor to account for ship specific design elements which reduce the capacity.

Capacity Depends on the ship type. For bulk carriers, gas carriers, tankers, general cargo ships, refrigerated cargo ships and combination carriers deadweight should be used as capacity. For cruise passenger ships, the capacity of the ship is computed as a function of the gross tonnage.

Capacity = $DWT_{Summer\ load\ draft}$

For container ships capacity is defined as 70 % of the deadweight at summer load draft

$Capacity_{Container} = 0.7 \cdot DWT_{Summer\ load\ draft}$

v_{ref} is the reference speed of the ship at EEDI conditions

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

for chemical tankers, as defined in regulation 1.16.1 of MARPOL Annex II, the following cubic capacity correction factor *fc* should apply:

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

or
f_c = 1.000, where *R* is 0.98 and above;

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) divided by the total cubic capacity of the cargo tanks of the ship (m^3). This factor is not to be applied to LNG carriers defined in regulation 2.38 of MARPOL Annex VI

For ro-ro passenger ships having a DWT/GT-ratio of less than 0.25, the cubic capacity correction factor fcRoPax is to be computed according to 2.12.3 of the IMO Calculation Guidelines.

For general cargo ships only equipped with cranes, side loaders or ro-ro ramps, the fl correction factor is to be computed according to 2.14 of the IMO Calculation Guidelines.

f_w is a correction factor to account the decrease of speed in representative sea conditions. F_w is not defined by IMO, yet, and hence is set to 1.

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Annex A

EEDI Technical File

Glossary

Abbreviations
DWT Deadweight Tonnage
GT Gross Tonnage
PTI Power take in
PTO Power take off
MCR Maximum continuous rating
MDO Marine Diesel Oil
SFC Specific fuel oil consumption

Subscripts
AE Auxiliary engine
ME Main engine
SG Shaft generator

Symbols
NO_x Nitrogen n-oxide
η_{SG} Shaft generator efficiency factor

A. Tables

Table A.1 General information

IMO no.	
BKI Reg. no.	
Ship name	
Ship type	
Ship builder	
Year of delivery	

Table A.2 Principal particulars

Parameter	**Value**	**Unit**	**remark**
L_{pp}		m	
B moulded		m	
Depth moulded		m	
Draft summer load line		m	to be taken from stability booklet
Lightship weight		t	from the lightship weight survey
DWT_{design}		t	to be taken from stability booklet
$DWTs_{ummer\ load\ draft}$		t	
$DWT_{70\ \%\ summer\ load\ draft}$		t	only for container ships

Table A.2 Principal particulars continued

Parameter	Value	Unit	remark
$Displacement_{ballast}$		t	from the sea trial report
$Displacement_{70\ \%\ DWT\ summer\ load\ draft}$		t	only for container ships
$Displacement_{design}$		t	to be taken from stability booklet
$Displacements_{ummer\ load\ draft}$		t	from the summer load draft stability booklet

Table A.3 Main engine(s) particulars

No. of engines		General arrangement
Manufacturer		to be taken from the NO_x Technical File
Type		
MCR		
SFC (corrected) at 75 % MCR		
Fuel type used for NO_x certification		

Table A.4 Auxiliary engine(s) particulars

No. of engines		General arrangement
Manufacturer		to be taken from the NO_x Technical File
Type		
MCR		
SFC (uncorrected)) at 50 % MCR SFC (ISO corrected) at 50 % MCR		to be taken from the NO_x Technical File ISO 8178
Fuel type used for NO_x certification		to be taken from the NO_x Technical File

Table A.5 Particulars of shaft generator

No. of shaft generators		General arrangement
Manufacturer		from the manufacturer's documentation
Power (PTO(i))		
Power (PTO(i))		
η_{SG}		

Table A.6 Particulars of shaft motors (PTO)

No. of shaft generators		General arrangement
Manufacturer		from the manufacturer's documentation
Power (PTO(i))		
Power (PTO(i))		
η_{SG}		

Table A.7 Particulars innovative electrical auxiliary systems

No. of systems		General arrangement
Manufacturer		from the manufacturer's documentation
Output capacity		
Availability factor		

Table A.8 Particulars of innovative technologies reducing main engine power for propulsion

No. of systems		General arrangement
Manufacturer		from the manufacturer's documentation
Mechanical output		
Availability factor		

Table A.9 Model test information

Model facility		General arrangement
Model scale		Model test report
Measured drafts		

Table A.10 Reference speed

Speed at EEDI conditions	

B. EEDI Calculation

The EEDI calculation shall be submitted. The calculation shall be complete and comprehensible as described in Section 2.

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