INTERNATIONAL MARITIME ORGANIZATION

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REPORT OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE ON ITS EIGHTY-FOURTH SESSION

Attached are annexes 12 to 20 to the report of the Marine Environment Protection Committee on its eighty-fourth session (MEPC 84/16).

(see documents MEPC 84/16/Add.1 for annexes 1 to 11 and MEPC 84/16/Add.3 for annexes 21 to 29)

LIST OF ANNEXES

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ANNEX 12

RESOLUTION MEPC.410(84)
(adopted on 1 May 2026)

AMENDMENTS TO THE 2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS

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 conferred upon it by international conventions for the prevention and control of marine pollution from ships,

NOTING that regulation 22 (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,

RECALLING that, at its seventy-ninth session, it adopted, by resolution MEPC.364(79), the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships,*

HAVING CONSIDERED, at its eighty-fourth session, draft amendments to the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*,

1 ADOPTS the amendments to the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships*, as set out in the annex to the present resolution;

2 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 groups;

3 AGREES to keep these Guidelines, as amended, under review, in light of the experience gained with their application.

ANNEX

AMENDMENTS TO THE 2022 GUIDELINES ON THE METHOD OF CALCULATION OF THE ATTAINED ENERGY EFFICIENCY DESIGN INDEX (EEDI) FOR NEW SHIPS (RESOLUTION MEPC.364(79))

1 In section 2.2.1, a new footnote is added after existing paragraph starting with "In the case of a ship equipped with a dual-fuel main or auxiliary engine" as follows:

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

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[*] For the purpose of this formula, the term "gas" may be taken to include any other fuel used in dual-fuel mode including liquid fuels.

2 In section 2.2.1, a new footnote is added after existing equation at the end of the section as follows:

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

[†] Both P_{ME} and SFC_{ME} should be determined based on the MCR certified in accordance with the NO_x Technical Code 2008. "

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ANNEX 13

RESOLUTION MEPC.411(84)
(adopted on 1 May 2026)

2026 GUIDELINES ON SURVEY AND CERTIFICATION OF THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee conferred upon it by international conventions for the prevention and control of marine pollution from ships,

NOTING that regulation 5 (Surveys) of MARPOL Annex VI, as amended, requires that ships to which chapter 4 of that Annex applies shall also be subject to survey and certification taking into account guidelines developed by the Organization,

RECALLING that, at its seventy-ninth session, it adopted, by resolution MEPC.365(79), the *2022 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*,

RECALLING ALSO that, at its eightieth session, it adopted, by resolution MEPC.374(80), amendments to the *2022 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*,

RECALLING FURTHER that, at its eighty-third session, it adopted, by resolution MEPC.403(83), amendments to the *2022 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*,

HAVING CONSIDERED, at its eighty-fourth session, draft amendments to the *2022 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*, as amended,

1 ADOPTS the *2026 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)* (2026 EEDI Survey and Certification Guidelines), as set out in the annex to the present resolution;

2 INVITES Administrations to implement the 2026 EEDI Survey and Certification Guidelines when developing and enacting national laws which give force to and implement provisions set forth in regulation 5 of MARPOL Annex VI, as amended;

3 REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the annexed Guidelines to the attention of shipowners, ship operators, shipbuilders, ship designers and any other interested groups;

4 AGREES to keep these Guidelines, as amended, under review, in light of the experience gained with their application;

5 AGREES that these Guidelines supersede the *2022 Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)* (resolution MEPC.365(79), as amended by resolutions MEPC.374(80) and MEPC.403(83)).

ANNEX

2026 GUIDELINES ON SURVEY AND CERTIFICATION OF THE ENERGY EFFICIENCY DESIGN INDEX (EEDI)

Table of contents

1 GENERAL

The purpose of these guidelines is to assist verifiers of the Energy Efficiency Design Index (EEDI) of ships in conducting the survey and certification of the EEDI, in accordance with regulations 5, 6, 7, 8 and 9 of MARPOL Annex VI, and assist shipowners, shipbuilders, manufacturers and other interested parties in understanding the procedures for the survey and certification of the EEDI.

2 DEFINITIONS[1]

2.1 *Verifier* means an Administration or organization duly authorized by it which conducts the survey and certification of the EEDI in accordance with regulations 5, 6, 7, 8 and 9 of MARPOL Annex VI and these guidelines.

2.2 *Ship of the same type* means a ship the hull form (expressed in the lines such as sheer plan and body plan), excluding additional hull features such as fins, and principal particulars of which are identical to that of the base ship.

2.3 *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 the approval of the verifier.

3 APPLICATION

These guidelines should be applied to new ships for which an application for an initial survey or an additional survey specified in regulation 5 of MARPOL Annex VI has been submitted to a verifier.

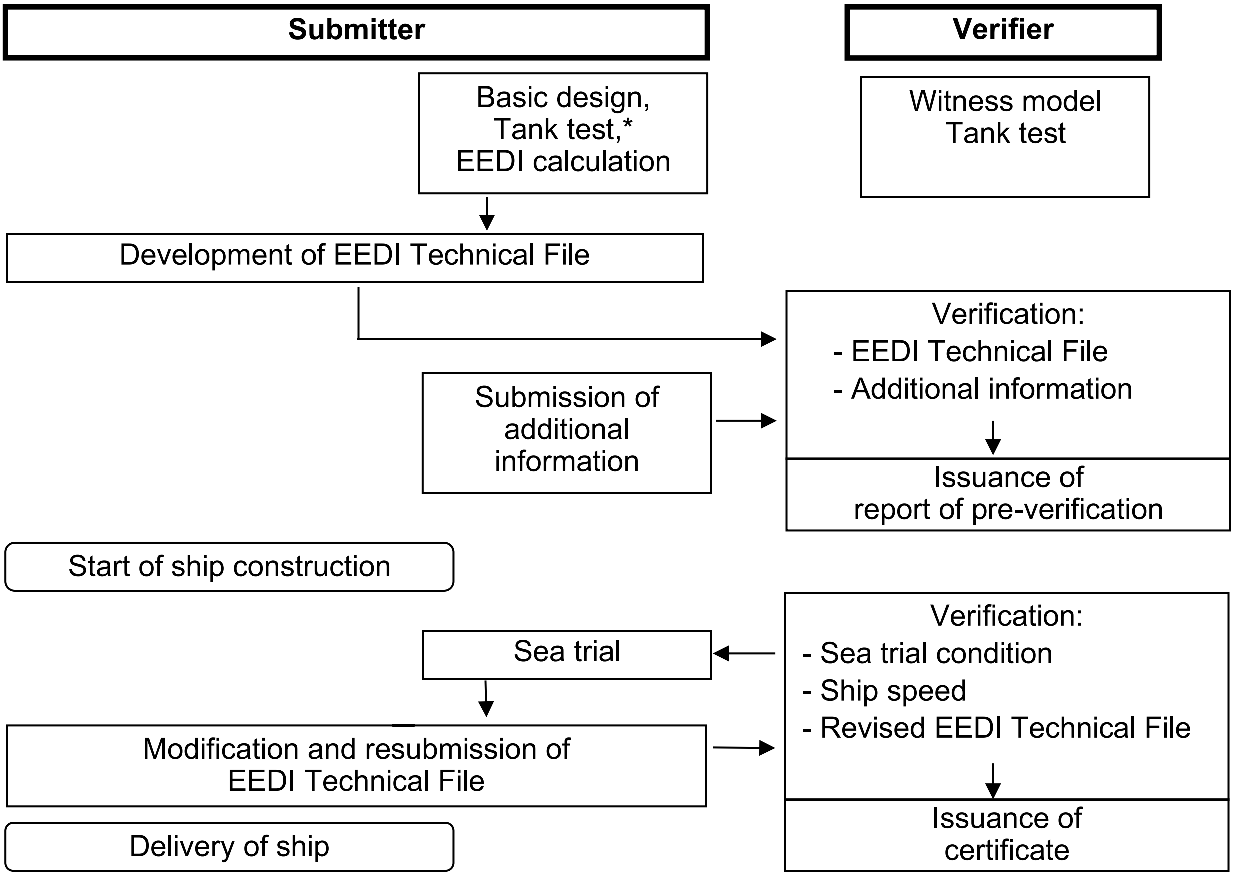
4 PROCEDURES FOR SURVEY AND CERTIFICATION

4.1 General

4.1.1 The attained EEDI should be calculated in accordance with regulation 22 of MARPOL Annex VI and the *2022 Guidelines on the method of calculation of the attained Energy Efficiency Design Index (EEDI) for new ships* (resolution MEPC.364(79), as amended) (EEDI Calculation Guidelines). Survey and certification of the EEDI should be conducted in two stages: preliminary verification at the design stage and final verification at the sea trial. The basic flow of the survey and certification process is presented in figure 1.

4.1.2 The information used in the verification process may contain confidential information of submitters which requires Intellectual Property Rights (IPR) protection. In the case where the submitter wants a non-disclosure agreement with the verifier, the additional information should be provided to the verifier upon mutually agreed terms and conditions.

1 Other terms used in these guidelines have the same meaning as those defined in the *2022 Guidelines on the method of calculation of the attained EEDI for new ships* (resolution MEPC.364(79), as amended).



* To be conducted by a test organization or a submitter.

Figure 1: Basic flow of survey and certification process

4.2 Preliminary verification of the attained EEDI at the design stage

4.2.1 For the preliminary verification at the design stage, an application for an initial survey and an EEDI Technical File containing the necessary information for the verification and other relevant background documents should be submitted to a verifier.

4.2.2 The EEDI Technical File should be written at least in English. The EEDI Technical File should include as a minimum, but not be limited to:

.1 deadweight (DWT) or gross tonnage (GT) for passenger and ro-ro passenger ships, the maximum continuous rating (MCR) of the main and auxiliary engines, the ship speed (V_{ref}), as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines, type of fuel, the specific fuel consumption (*SFC*) of the main engine at 75% of MCR power, the *SFC* of the auxiliary engines at 50% MCR power, and the electric power table[2] for certain ship types, as necessary, as defined in the EEDI Calculation Guidelines;

2 Electric power table should be validated separately, taking into account guidelines set out in appendix 2 to these Guidelines.

.2 power curve(s) (kW – knot) estimated at design stage under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines, and, in the event that the sea trial is carried out in a condition other than the above condition, also a power curve estimated under the sea trial condition;

.3 principal particulars, ship type and the relevant information to classify the ship as such a ship type, classification notations and an overview of the propulsion system and electricity supply system on board;

.4 estimation process and methodology of the power curves at design stage;

.5 description of energy-saving equipment;

.6 calculated value of the attained EEDI, including 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;

.7 calculated values of the attained $EEDI_{weather}$ and f_w value (not equal to 1.0), if those values are calculated, based on the EEDI Calculation Guidelines; and

.8 for LNG carriers:

.1 type and outline of propulsion systems (such as direct drive diesel, diesel electric, steam turbine);

.2 LNG cargo tank capacity in m^3 and BOR as defined in paragraph 2.2.5.6.3 of the EEDI Calculation Guidelines;

.3 shaft power of the propeller shaft after transmission gear at 100% of the rated output of motor (MPP_{Motor}) and $\eta_{(i)}$ for diesel electric;

.4 maximum continuous rated power ($MCR_{SteamTurbine}$) for steam turbine; and

.5 $SFC_{SteamTurbine}$ for steam turbine, as specified in paragraph 2.2.7 of the EEDI Calculation Guidelines.

A sample of an EEDI Technical File is provided in appendix 1 to these guidelines.

4.2.3 For ships equipped with dual-fuel engine(s) using LNG and fuel oil, the C_F factor for gas (LNG) and the specific fuel consumption (SFC) of gas fuel should be used by applying the following criteria as a basis for the guidance of the Administration:[3]

.1 final decision on the primary fuel rests with the Administration;

.2 the ratio of calorific value of gas fuel (LNG) to total marine fuels (HFO/MGO), including gas fuel (LNG) at design conditions should be equal or larger than 50% in accordance with the formula below. However, the Administration can accept a lower value of the percentage taking into account the intended voyages:

[3] For the purpose of this paragraph, the terms "LNG" and "gas" may be taken to include any fuel used in dual-fuel mode including liquid fuels.

$$\frac{V_{gas} \times \rho_{gas} \times LCV_{gas} \times K_{gas}}{\left(\sum_{i=1}^{nLiquid} V_{liquid(i)} \times \rho_{liquid(i)} \times LCV_{liquid(i)} \times K_{liquid(i)} \right) + V_{gas} \times \rho_{gas} \times LCV_{gas} \times K_{gas}} \geq 50\%$$

Whereby,

V_{gas} is the total net tank volume of gas fuel on board in m^3;

V_{liquid} is the total net tank volume of every liquid fuel on board in m^3;

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

ρ_{liquid} is the density of every 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.

Normal density, Low Calorific Value and filling rate for tanks of different kinds of fuel are listed below.

Type of fuel	Density (kg/m^3)	Low Calorific Value (kJ/kg)	Filling rate for tanks
Diesel/Gas Oil	900	42,700	0.98
Heavy Fuel Oil	991	40,200	0.98
Liquefied Natural Gas (LNG)	450	48,000	0.95*

* Subject to verification of tank loading limit in the IGF and/or IGC Codes, where applicable, corresponding to the normal density used in the calculation of f_{DFgas}

Note: In case of other fuels, the low calorific value should be taken from the 2022 EEDI Calculation Guidelines (resolution MEPC.364(79), as amended), where available. If not listed, values consistent with industry standards should be applied. Density values should correspond to industry standards. Filling rate for tanks values should reflect the applicable design specifications.

.3 in case the ship is not fully equipped with dual-fuel engines, the C_F factor for gas (LNG) should apply only for those installed engines that are of dual-fuel type and sufficient gas fuel supply should be available for such engines; and

.4 LNG fuelling solutions with exchangeable (specialized) LNG tank-containers should also fall under the terms of LNG as primary fuel.

4.2.4 The *SFC* of the main and auxiliary engines should be quoted from the approved NO_x Technical File and should be corrected to the value corresponding to the ISO standard reference conditions using the standard lower calorific value of the fuel oil (42,700 kJ/kg), referring to ISO 15550:2002 and ISO 3046-1:2002. For the confirmation of the *SFC*, a copy of the approved NO_x Technical File and documented summary of the correction calculations should be submitted to the verifier. In cases where the NO_x Technical File has not been approved at the time of the application for initial survey, the test reports provided by manufacturers should be used. In this case, at the time of the sea trial verification, a copy of the approved NO_x Technical File and documented summary of the correction calculations should be submitted to the verifier. In the case that gas fuel is determined as primary fuel in accordance with paragraph 4.2.3 and that installed engine(s) have no approved NO_x Technical File tested in gas mode, the *SFC* of gas mode should be submitted by the manufacturer and confirmed by the verifier.

> **Note:** *SFC* in the NO_x Technical File are the values of a parent engine, and the use of such value of *SFC* for the EEDI calculation for member engines may have the following technical issues for further consideration:
>
> .1 the definition of "member engines" given in the NO_x Technical File is broad and specification of engines belonging to the same group/family may vary; and
>
> .2 the rate of NO_x emission of the parent engine is the highest in the group/family – i.e. CO_2 emission, which is in the trade-off relationship with NO_x emission, can be lower than the other engines in the group/family.

4.2.5 For ships to which regulation 24 of MARPOL Annex VI applies, the power curves used for the preliminary verification at the design stage should be based on reliable results of tank tests. A tank test for an individual ship may be omitted based on technical justifications such as availability of the results of tank tests for ships of the same type. In addition, the omission of tank tests is acceptable for a ship for which sea trials will be carried out under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines, upon agreement of the shipowner and shipbuilder and with the approval of the verifier. To ensure the quality of tank tests, the ITTC quality system should be taken into account. Model tank tests should be witnessed by the verifier.

> **Note:** It would be desirable in the future that an organization conducting a tank test be authorized.

4.2.6 The verifier may request further information from the submitter, in addition to that contained in the EEDI Technical File, as necessary, to examine the calculation process of the attained EEDI. For the estimation of the ship speed at the design stage much depends on each shipbuilder's experience, and it may not be practicable for any person/organization other than the shipbuilder to fully examine the technical aspects of experience-based parameters, such as the roughness coefficient and wake scaling coefficient. Therefore, the preliminary verification should focus on the calculation process of the attained EEDI to ensure that it is technically sound and reasonable and follows regulation 22 of MARPOL Annex VI and the EEDI Calculation Guidelines.

> **Note 1:** A possible way forward for more robust verification is to establish a standard methodology of deriving the ship speed from the outcome of tank tests, by setting standard values for experience-based correction factors such as roughness coefficient and wake scaling coefficient. In this way, ship-by-ship performance comparisons could be made more objectively by excluding the possibility of arbitrary setting of experience-based parameters. If such standardization is sought, this would have an implication on how the ship speed adjustment based on sea trial results should be conducted, in accordance with paragraph 4.3.8 of these guidelines.
>
> **Note 2:** A joint industry standard to support the method and role of the verifier is expected to be developed.

4.2.7 Additional information that the verifier may request the submitter to provide includes, but is not limited to:

.1 descriptions of a tank test facility; this should include the name of the facility, the particulars of tanks and towing equipment, and the records of calibration of each monitoring equipment;

.2 lines of a model ship and an actual ship for the verification of the appropriateness of the tank test; the lines (sheer plan, body plan and half-breadth plan) should be detailed enough to demonstrate the similarity between the model ship and the actual ship;

.3 lightweight of the ship and displacement table for the verification of the deadweight;

.4 detailed report on the method and results of the tank test; this should include at least the tank test results at sea trial condition and under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines;

.5 detailed calculation process of the ship speed, which should include the basis for the estimation of experience-based parameters such as roughness coefficient, and wake scaling coefficient;

.6 reasons for exempting a tank test, if applicable; this should include lines and tank test results of ships of the 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; and

.7 for LNG carriers, detailed calculation process of P_{AE} and $SFC_{SteamTurbine}$.

4.2.8 The verifier should issue the report on the Preliminary Verification of the EEDI after it has verified the attained EEDI at the design stage, in accordance with paragraphs 4.1 and 4.2 of these guidelines.

4.3 Final verification of the attained EEDI at sea trial

4.3.1 Sea trial conditions should be set as the conditions specified in paragraph 2.2.2 of the EEDI Calculation Guidelines, if possible.

4.3.2 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 the NO_x Technical File, as necessary. The test procedure should include, as 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.

4.3.3 The verifier should attend the sea trial and confirm:

.1 propulsion and power supply system, particulars of the engines or steam turbines, and other relevant items described in the EEDI Technical File;

.2 draught and trim;

.3 sea conditions;

.4 ship speed; and

.5 shaft power and RPM.

4.3.4 Draught and trim should be confirmed by the draught measurements taken prior to the sea trial. The draught and trim should be as close as practical to those at the assumed conditions used for estimating the power curves.

4.3.5 Sea conditions should be measured in accordance with ITTC Recommended Procedure 7.5-04-01-01.1 *Preparation, Conduct and Analysis of Speed/Power Trials* 2024 or ISO 15016:2025.[4]

4.3.6 Ship speed should be measured in accordance with ITTC Recommended Procedure 7.5-04-01-01.1 *Preparation, Conduct and Analysis of Speed/Power Trials* 2024 or ISO 15016:2025,[4] and at more than two points of which range includes the power of the main engine as specified in paragraph 2.2.5 of the EEDI Calculation Guidelines.

4.3.7 The main engine output, shaft power of propeller shaft (for LNG carriers having diesel electric propulsion system) or steam turbine output (for LNG carriers having steam turbine propulsion system) should be measured by shaft power meter or a method which the engine manufacturer recommends and the verifier approves. Other methods may be acceptable upon agreement of the shipowner and shipbuilder and with the approval of the verifier.

4.3.8 The submitter should develop power curves based on the measured ship speed and the measured output of the main engine at sea trial. For the development of the power curves, the submitter should calibrate the measured ship speed, if necessary, by taking into account the effects of wind, current, waves, shallow water, displacement, water temperature and water density in accordance with ITTC Recommended Procedure 7.5-04-01-01.1 *Preparation, Conduct and Analysis of Speed/Power Trials* 2024 or ISO 15016:2025.[4] Upon agreement with the shipowner, the submitter should submit a report on the speed trials including details of the power curve development to the verifier for verification.

4.3.9 The submitter 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:

.1 for ships for which sea trial is conducted under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines: the attained EEDI should be recalculated using the measured ship speed at sea trial at the power of the main engine as specified in paragraph 2.2.5 of the EEDI Calculation Guidelines; and

.2 for ships for which sea trial cannot be conducted under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines: if the measured ship speed at the power of the main engine as specified in paragraph 2.2.5 of the EEDI Calculation Guidelines 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 paragraph 2.2.2 of the EEDI Calculation Guidelines by an appropriate correction method that is agreed by the verifier.

[4] Until 1 May 2026, ISO 15016:2015 may also be used.

An example of scheme of conversion from trial condition to EEDI condition at EEDI power is given as follows:

V_{ref} is obtained from the results of the sea trials at trial condition using the speed-power curves predicted by the tank tests. The tank tests shall be carried out at both draughts: trial condition corresponding to that of the S/P trials and EEDI condition. For trial conditions the power ratio α_P between model test prediction and sea trial result is calculated for constant ship speed. Ship speed from model test prediction for EEDI condition at EEDI power multiplied with α_P is V_{ref}.

$$\alpha_P = \frac{P_{Trial,P}}{P_{Trial,S}}$$

where:

$P_{Trial,P}$: power at trial condition predicted by the tank tests

$P_{Trial,S}$: power at trial condition obtained by the S/P trials

α_P : power ratio

Figure 2 shows an example of scheme of the conversion to derive the resulting ship speed at EEDI condition (V_{ref}) at EEDI power.

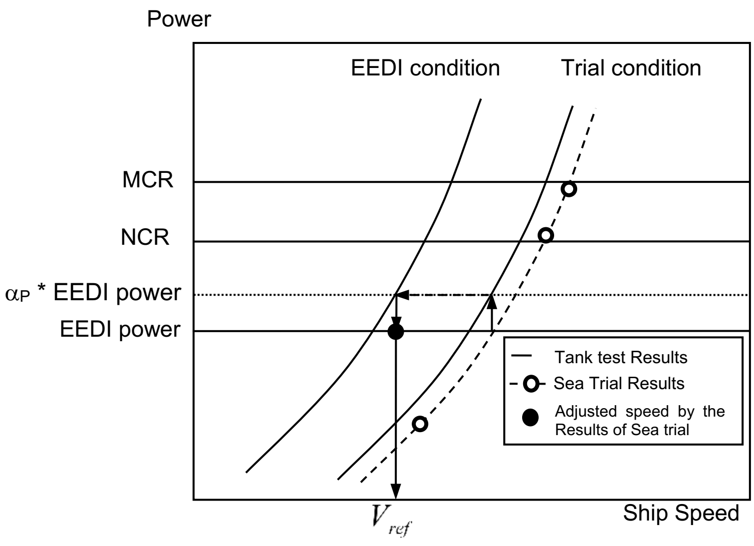


Figure 2: An example of scheme of conversion from trial condition to EEDI condition at EEDI power

Note: Further consideration would be necessary for speed adjustment methodology in paragraph 4.3.9.2 of these guidelines. One of the concerns relates to a possible situation where the power curve for sea trial condition is estimated in an excessively conservative manner (i.e. power curve is shifted in a leftward direction) with the intention to get an upward adjustment of the ship speed by making the measured ship speed at sea trial easily exceed the lower-estimated speed for sea trial condition at design stage.

4.3.10 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 submitter 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.

4.3.11 The electrical efficiency $\eta_{(i)}$ should be taken as 91.3% for the purpose of calculating the attained EEDI. Alternatively, if a value of more than 91.3% is to be applied, $\eta_{(i)}$ should be obtained by measurement and verified by a method approved by the verifier.

4.3.12 In cases where the attained EEDI is calculated at the preliminary verification by using *SFC* based on the manufacturer's test report, owing 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. Also, for steam turbines, the EEDI should be recalculated by using *SFC* confirmed by the Administration or an organization recognized by the Administration at the sea trial.

4.3.13 The EEDI Technical File should be revised, as necessary, by taking into account the results of sea trials. Such revision should include, as applicable, the adjusted power curve based on the results of sea trials (namely, modified ship speed under the condition as specified in paragraph 2.2.2 of the EEDI Calculation Guidelines), the finally determined deadweight/gross tonnage, η for LNG carriers having diesel electric propulsion system and *SFC* described in the approved NO_x Technical File, and the recalculated attained EEDI based on these modifications.

4.3.14 The EEDI Technical File, if revised, should be submitted to the verifier for confirmation that the (revised) attained EEDI is calculated in accordance with regulation 22 of MARPOL Annex VI and the EEDI Calculation Guidelines.

4.4 Verification of the attained EEDI in case of major conversion

4.4.1 In cases of a major conversion of a ship, the shipowner 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.

4.4.2 The background documents should include as a minimum, but are not limited to:

.1 details of the conversion;

.2 EEDI parameters changed after the conversion and the technical justifications for each respective parameter;

.3 reasons for other changes made in the EEDI Technical File, if any; and

.4 calculated value of the attained EEDI with the calculation summary, which should contain, as a minimum, each value of the calculation parameters and the calculation process used to determine the attained EEDI after the conversion.

4.4.3 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 22 of MARPOL Annex VI and the EEDI Calculation Guidelines.

4.4.4 For verification of the attained EEDI after a conversion, speed trials of the ship are required, as necessary.

APPENDIX 1

SAMPLE OF EEDI TECHNICAL FILE

1 Data

1.1 General information

Shipbuilder	JAPAN Shipbuilding Company
Hull no.	12345
IMO no.	94111XX
Ship type	Bulk carrier

1.2 Principal particulars

Length overall	250.0 m
Length between perpendiculars	240.0 m
Breadth, moulded	40.0 m
Depth, moulded	20.0 m
Summer load line draught, moulded	14.0 m
Deadweight at summer load line draught	150,000 tons

1.3 Main engine

Manufacturer	JAPAN Heavy Industries Ltd.
Type	6J70A
Maximum continuous rating (MCR)	15,000 kW x 80 rpm
SFC at 75% MCR	165.0 g/kWh
Number of set	1
Fuel type	Diesel Oil

1.4 Auxiliary engine

Manufacturer	JAPAN Diesel Ltd.
Type	5J-200
Maximum continuous rating (MCR)	600 kW x 900 rpm
SFC at 50% MCR	220.0 g/kWh
Number of set	3
Fuel type	Diesel Oil

1.5 Ship speed

Ship speed in deep water at summer load line draught at 75% of MCR	14.25 knots

2 Power curves

The power curves estimated at the design stage and modified after the speed trials are shown in figure 2.1.

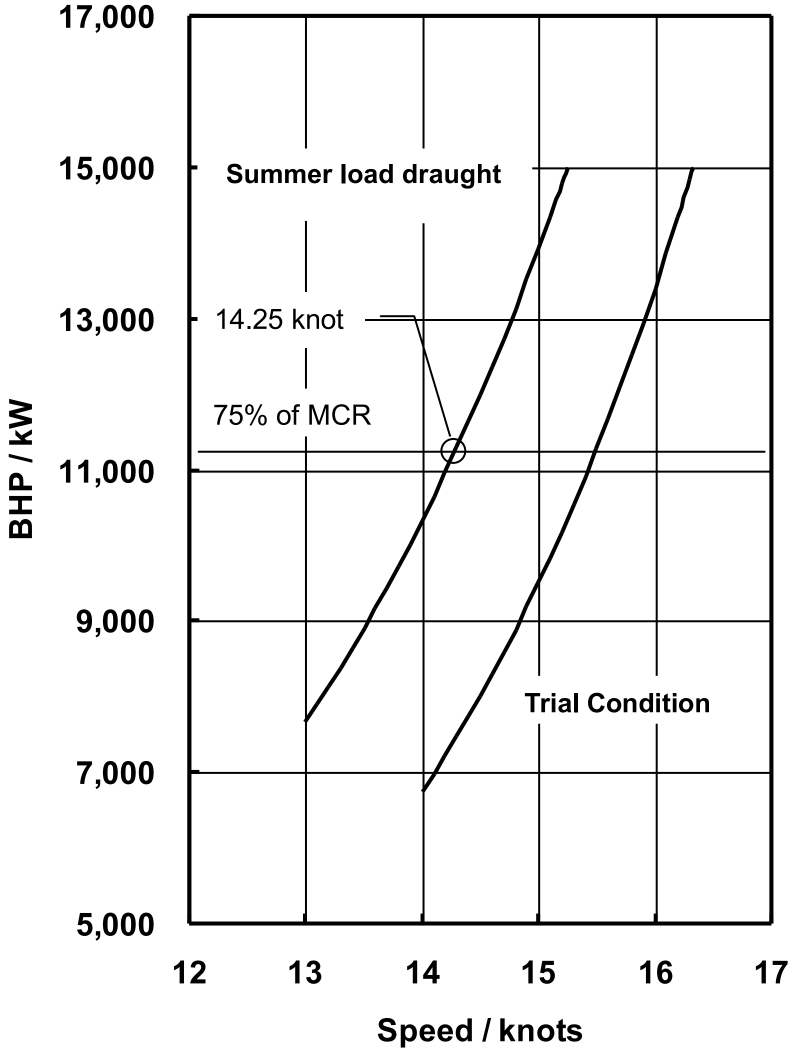


Figure 2.1: Power curves

3 Overview of propulsion system and electric power supply system

3.1 Propulsion system

3.1.1 Main engine
Refer to paragraph 1.3 of this appendix.

3.1.2 Propeller

Type	Fixed pitch propeller
Diameter	7.0 m
Number of blades	4
Number of set	1

3.2 Electric power supply system

3.2.1 Auxiliary engines
Refer to paragraph 1.4 of this appendix.

3.2.2 Main generators

Manufacturer	JAPAN Electric
Rated output	560 kW (700 kVA) x 900 rpm
Voltage	AC 450 V
Number of set	3

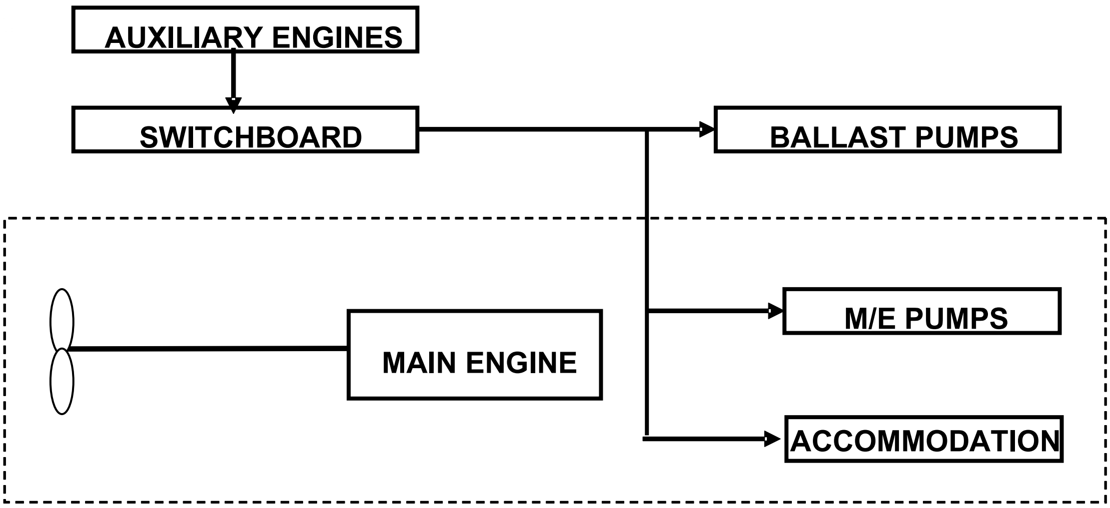


Figure 3.1: Schematic figure of propulsion and electric power supply system

4 Estimation process of power curves at design stage

Power curves are estimated based on model test results. The flow of the estimation process is shown below.

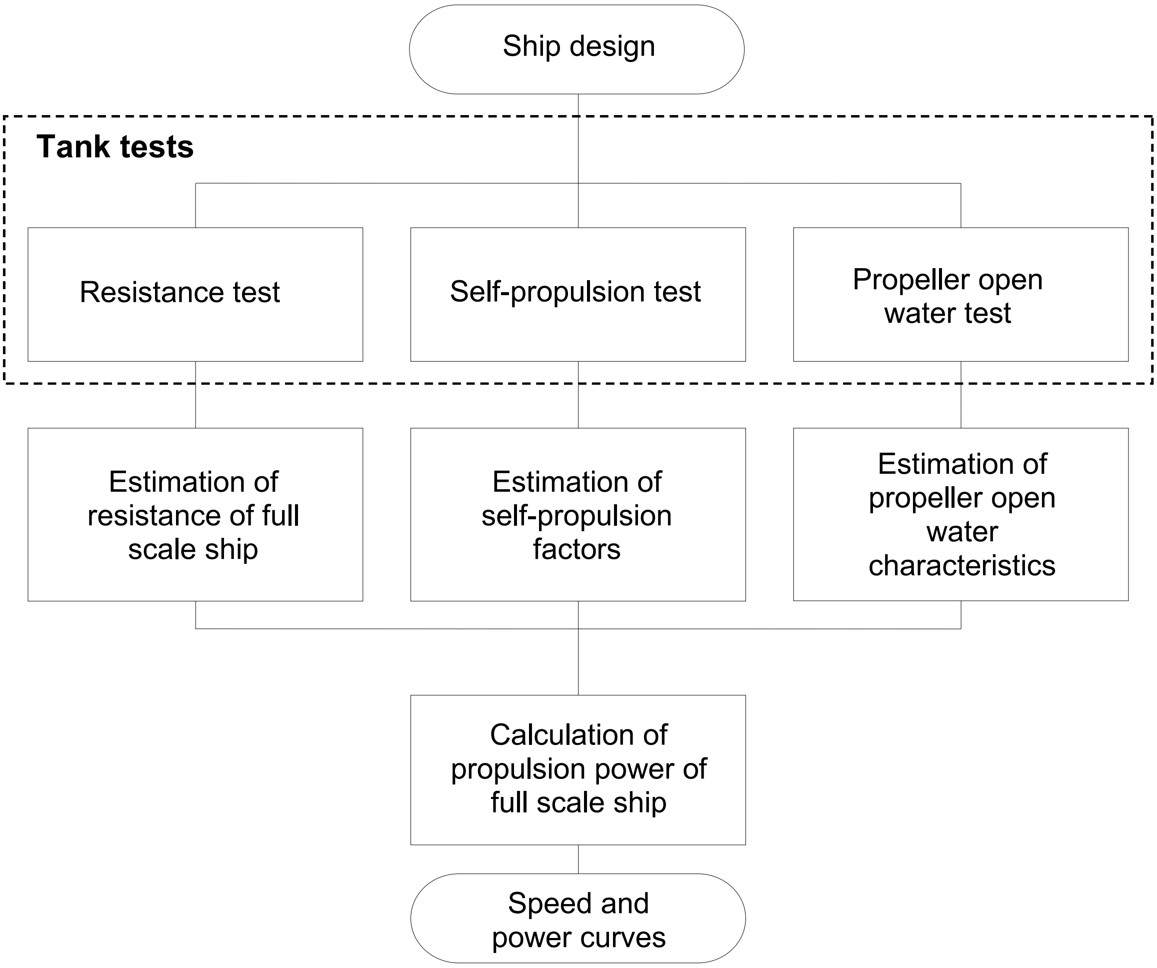


Figure 4.1: Flow chart of process for estimating power curves

5 Description of energy-saving equipment

5.1 Energy-saving equipment the effects of which are expressed as $P_{AEeff(i)}$ and/or $P_{eff(i)}$ in the EEDI calculation formula

N/A

5.2 Other energy-saving equipment

(Example)

5.2.1 Rudder fins

5.2.2 Propeller boss cap fins

……
(Specifications, schematic figures and/or photos, etc., for each piece of equipment or device should be indicated. Alternatively, attachment of a commercial catalogue may be acceptable.)

6 Calculated value of attained EEDI

6.1 Basic data

Type of ship	Capacity DWT	Speed V_{ref} (knots)
Bulk Carrier	150,000	14.25

6.2 Main engine

MCR_{ME} (kW)	Shaft gen.	P_{ME} (kW)	Type of fuel	C_{FME}	SFC_{ME} (g/kWh)
15,000	N/A	11,250	Diesel Oil	3.206	165.0

6.3 Auxiliary engines

P_{AE} (kW)	Type of fuel	C_{FAE}	SFC_{AE} (g/kWh)
625	Diesel Oil	3.206	220.0

6.4 Ice class

N/A

6.5 Innovative electrical energy-efficient technology

N/A

6.6 Innovative mechanical energy-efficient technology

N/A

6.7 Cubic capacity correction factor

N/A

6.8 Calculated value of attained EEDI

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

$$= \frac{1 \times (11250 \times 3.206 \times 165.0) + (625 \times 3.206 \times 220.0) + 0 - 0}{1 \cdot 1 \cdot 150000 \cdot 1 \cdot 14.25}$$

$$= 2.99 \quad (\mathrm{g - CO_2/ton \cdot mile})$$

attained EEDI: 2.99 g-CO_2/ton mile

7 Calculated value of attained $EEDI_{weather}$

7.1 Representative sea conditions

	Mean wind speed	Mean wind direction	Significant wave height	Mean wave period	Mean wave direction
BF6	12.6 (m/s)	0 (deg.)*	3.0 (m)	6.7 (s)	0 (deg.)*

* Heading direction of wind/wave in relation to the ship's heading, i.e. 0 (deg.) means the ship is heading directly into the wind.

7.2 Calculated weather factor, f_w

f_w	0.900

7.3 Calculated value of attained $EEDI_{weather}$

attained $EEDI_{weather}$: 3.32 g-CO_2/ton mile

APPENDIX 2

GUIDELINES FOR VALIDATION OF ELECTRIC POWER TABLES FOR EEDI (EPT-EEDI)

1 INTRODUCTION

The purpose of these guidelines is to assist recognized organizations in the validation of electric power tables (EPT) for the calculation of the Energy Efficiency Design Index (EEDI) for ships. As such, these guidelines support the implementation of the EEDI Calculation Guidelines and the *Guidelines on survey and certification of the Energy Efficiency Design Index (EEDI)*. These guidelines will also assist shipowners, shipbuilders, ship designers and manufacturers in relation to aspects of the development of more energy-efficient ships and also in understanding the procedures for the EPT-EEDI validation.

2 OBJECTIVES

These guidelines provide a framework for the uniform application of the EPT-EEDI validation process for ships for which required auxiliary engine power is calculated under paragraph 2.2.5.7 of the EEDI Calculation Guidelines.

3 DEFINITIONS

3.1 *Applicant* means an organization, primarily a shipbuilder or a ship designer, which requests the EPT-EEDI validation in accordance with these guidelines.

3.2 *Validator* means a recognized organization which conducts the EPT-EEDI validation in accordance with these guidelines.

3.3 *Validation* for the purpose of these Guidelines means review of submitted documents and survey during construction and sea trials.

3.4 *Standard EPT-EEDI-Form* refers to the layout given in appendix 3, containing the EPT-EEDI results that will be the subject of validation. Other supporting documents submitted for this purpose will be used as reference only and will not be subject to validation.

3.5 P_{AE} herein is defined as per the definition in paragraph 2.2.5.6 of the EEDI Calculation Guidelines.

3.6 *Ship service and engine-room loads* refer to all the load groups which are needed for the hull, deck, navigation and safety services, propulsion and auxiliary engine services, engine-room ventilation and auxiliaries and ship's general services.

3.7 *Diversity factor* is the ratio of the "total installed load power" and the "actual load power" for continuous loads and intermittent loads. This factor is equivalent to the product of service factors for load, duty and time.

4 APPLICATION

4.1 These guidelines are applicable to ships as stipulated in paragraph 2.2.5.7 of the EEDI Calculation Guidelines.

4.2 These guidelines should be applied for new ships for which an application for an EPT-EEDI validation has been submitted to a validator.

4.3 The steps of the validation process include:

.1 review of documents during the design stage

.1 check if all relevant loads are listed in the EPT;

.2 check if reasonable service factors are used; and

.3 check the correctness of the P_{AE} calculation based on the data given in the EPT.

.2 survey of installed systems and components during construction stage

.1 check if a randomly selected set of installed systems and components are correctly listed with their characteristics in the EPT.

.3 survey of sea trials

.1 check if selected units/loads specified in EPT are observed.

5 SUPPORTING DOCUMENTS

5.1 The applicant should provide as a minimum the ship electric balance load analysis.

5.2 Such information may contain shipbuilders' confidential information. Therefore, after the validation, the validator should return all or part of such information to the applicant at the applicant's request.

5.3 A special EEDI condition during sea trials may be needed and defined for each ship and included in the sea trial schedule. For this condition, a special column should be inserted into the EPT.

6 PROCEDURES FOR VALIDATION

6.1 General

P_{AE} should be calculated in accordance with the EPT-EEDI Calculation Guidelines. EPT-EEDI validation should be conducted in two stages: preliminary validation at the design stage and final validation during sea trials. The validation process is presented in figure 1.

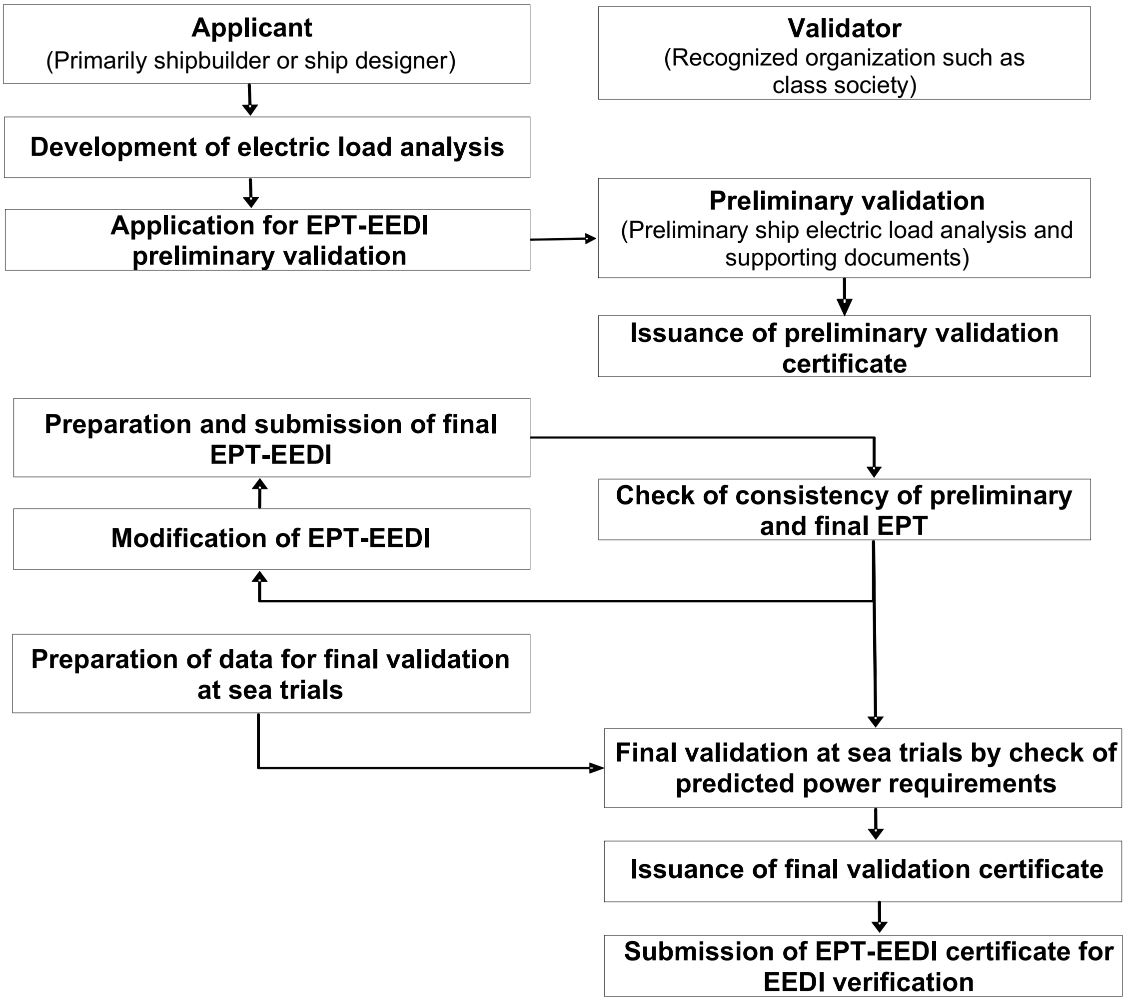


Figure 1: Basic flow of EPT-EEDI validation process

6.2 Preliminary validation at the design stage

6.2.1 For the preliminary validation at the design stage, the applicant should submit to a validator an application for the validation of EPT-EEDI, inclusive of the EPT-EEDI Form, and all the relevant and necessary information for the validation as supporting documents.

6.2.2 The applicant should supply as a minimum the supporting data and information, as specified in appendix A (to be developed).

6.2.3 The validator may request from the applicant additional information to that contained in these Guidelines, as necessary, to enable the validator to examine the calculation process of the EPT-EEDI. The estimation of the ship EPT-EEDI at the design stage depends on each applicant's experience, and it may not be practicable to fully examine the technical aspects and details of each machinery component. Therefore, the preliminary validation should focus on the calculation process of the EPT-EEDI that should follow best marine practices.

> **Note:** A possible way forward for more robust validation is to establish a standard methodology of deriving the ship EPT by setting standard formats as agreed and used by industry.

6.3 Final validation

6.3.1 The final validation process should as a minimum include a check of the ship electric load analysis to ensure that all electric consumers are listed, and that their specific data and the calculations in the power table itself are correct and are supported by sea trial results. If necessary, additional information has to be requested.

6.3.2 For the final validation, the applicant should revise the EPT-EEDI Form and supporting documents as necessary, by taking into account the characteristics of the machinery and other electrical loads actually installed on board the ship. The EEDI condition at sea trials should be defined and the expected power requirements in these conditions documented in the EPT. Any changes within the EPT from design stage to construction stage should be highlighted by the shipyard.

6.3.3 The preparation for the final validation includes a desktop check comprising:

.1 consistency of preliminary and final EPT;

.2 changes of service factors (compared to the preliminary validation);

.3 all electric consumers are listed;

.4 their specific data and the calculations in the power table itself are correct; and

.5 in case of doubt, component specification data is checked in addition.

6.3.4 A survey prior to sea trials is performed to ensure that machinery characteristics and data as well as other electric loads comply with those recorded in the supporting documents. This survey does not cover the complete installation but selects randomly a number of samples.

6.3.5 For the purpose of sea trial validation, the surveyor will check the data of selected systems and/or components given in the special column added to the EPT for this purpose or the predicted overall value of electric load by means of practicable measurements with the installed measurement devices.

7 ISSUANCE OF THE EPT-EEDI STATEMENT OF VALIDATION

7.1 The validator should stamp the EPT-EEDI Form as "Noted" having validated the EPT-EEDI in the preliminary validation stage, in accordance with these guidelines.

7.2 The validator should stamp the EPT-EEDI Form as "Endorsed" having validated the final EPT-EEDI in the final validation stage in accordance with these guidelines.

APPENDIX 3

ELECTRIC POWER TABLE FORM FOR ENERGY EFFICIENCY DESIGN INDEX (EPT-EEDI FORM) AND STATEMENT OF VALIDATION

Ship ID:
IMO no.: ____________________________
Ship's name:_________________________
Shipyard:___________________________
Hull no.:____________________________

Applicant:
Name:_______________________________________
Address:_____________________________________
____

Validation stage:
☐ Preliminary validation
☐ Final validation

Summary results of EPT-EEDI

Load group	Seagoing condition EEDI Calculation Guidelines		Remarks
	Continuous load (kW)	**Intermittent load (kW)**	
Ship service and engine-room loads			
Accommodation and cargo loads			
Total installed load			
Diversity factor			
Normal seagoing load			
Weighted average efficiency of generators			
P_{AE}			

Supporting documents

Title	ID or remarks

Validator details:
Organization: ____________________________________
Address: ____________________________________
____

This is to certify that the above-mentioned electrical loads and supporting documents have been reviewed in accordance with EPT-EEDI Validation guidelines and the review shows a reasonable confidence for use of the above P_{AE} in EEDI calculations.

Date of review:________________ Statement of validation no._______

This statement is valid on condition that the electric power characteristics of the ship do not change.

Signature of Validator

____
Printed name:

***

ANNEX 14

RESOLUTION MEPC.412(84)
(adopted on 1 May 2026)

AMENDMENTS TO THE 2022 GUIDELINES ON OPERATIONAL CARBON INTENSITY INDICATORS AND THE CALCULATION METHODS (CII GUIDELINES, G1)

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,

NOTING that regulation 28.1 of MARPOL Annex VI requires ships to which this regulation apply to calculate the attained annual operational CII taking into account the guidelines developed by the Organization,

RECALLING that, at its seventy-eighth session, it adopted, by resolution MEPC.352(78), the *2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1)*,

HAVING CONSIDERED, at its eighty-fourth session, draft amendments to the *2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1)*,

1 ADOPTS the amendments to the *2022 Guidelines on operational carbon intensity indicators and the calculation methods (CII Guidelines, G1)*, as set out in the annex to the present resolution;

2 INVITES Administrations to take the amendments into account when developing and enacting national laws which give force to and implement requirements set forth in regulation 28.1 of MARPOL Annex VI;

3 REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the amendments to the attention of masters, seafarers, shipowners, ship operators and any other interested parties;

4 AGREES to keep the Guidelines, as amended, under review, in light of experience gained with their implementation.

ANNEX

AMENDMENTS TO THE 2022 GUIDELINES ON OPERATIONAL CARBON INTENSITY INDICATORS AND THE CALCULATION METHODS (CII GUIDELINES, G1) (RESOLUTION MEPC.352(78))

1 Section 4.2 is replaced with the following:

"*4.2 Transport work (W)*

While transport work (*W*) may be determined from the data on actual transport work* as reported under the IMO DCS, the supply-based transport work (*Ws*) should continue to be used as a proxy for the calculation of the attained annual operational CII of individual ships. The supply-based transport work (*Ws*) is defined as the product of a ship's capacity and the total distance travelled (both under way and not under way) in a given calendar year, as follows:

$$Ws = C \times D_t \qquad (3)$$

where:

- *C* represents the ship's capacity:
  - For bulk carriers, tankers, container ships, gas carriers, LNG carriers, general cargo ships, refrigerated cargo carrier and combination carriers, deadweight tonnage (DWT)[1] should be used as Capacity;
  - For cruise passenger ships, ro-ro cargo ships (vehicle carriers), ro-ro cargo ships and ro-ro passenger ships, gross tonnage (GT)[2] should be used as Capacity; and
- D_t represents the total distance travelled (in nautical miles), as reported under IMO DCS.

*Note: Data on actual transport work reported under the enhanced granularity of the IMO DCS may be considered for analytical purposes during the phase 2 of the review of the CII framework."

***

[1] Deadweight tonnage (DWT) means the difference in tonnes between the displacement of a ship in water of relative density of 1,025 kg/m^3 at the summer load draught and the lightweight of the ship. The summer load draught should be taken as the maximum summer draught as certified in the stability booklet approved by the Administration or any organization recognized by it.

[2] Gross tonnage (GT) should be calculated in accordance with the International Convention on Tonnage Measurement of Ships, 1969.

ANNEX 15

RESOLUTION MEPC.413(84)
(adopted on 1 May 2026)

AMENDMENTS TO THE 2024 GUIDELINES FOR THE DEVELOPMENT OF A SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP)

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,

NOTING that regulation 26 of MARPOL Annex VI requires each ship to keep on board a Ship Energy Efficiency Management Plan (SEEMP), to be developed and reviewed, taking into account the guidelines adopted by the Organization,

RECALLING that, at its eighty-second session, it adopted, by resolution MEPC.395(82), the 2024 *Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)*,

RECALLING ALSO that, at its eighty-third session, it adopted, by resolution MEPC.401(83), amendments to the 2024 *Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)*,

HAVING CONSIDERED, at its eighty-fourth session, draft amendments to the *2024 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)*,

1 ADOPTS amendments to the *2024 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP)*, the text of which is set out in the annex to the present resolution;

2 REQUESTS the Parties to MARPOL Annex VI and other Member Governments to bring the amendments to the attention of masters, seafarers, shipowners, ship operators and any other interested parties.

3 AGREES to keep these Guidelines, as amended, under review, in light of the experience gained with their application.

ANNEX

AMENDMENTS TO THE 2024 GUIDELINES FOR THE DEVELOPMENT OF A SHIP ENERGY EFFICIENCY MANAGEMENT PLAN (SEEMP) (RESOLUTION MEPC.395(82), AS AMENDED BY RESOLUTION MEPC.401(83))

PART II - SHIP FUEL OIL CONSUMPTION DATA-COLLECTION PLAN

7 GUIDANCE ON METHODOLOGY FOR COLLECTING DATA ON FUEL OIL CONSUMPTION, DISTANCE TRAVELLED AND HOURS UNDER WAY AND OTHER ITEMS

Distance travelled

1 The title of the section on "Distance travelled" is replaced with "Total distance travelled".

2 In paragraph 7.7, sub-paragraph 7.7.2 is replaced with the following:

".2 the distance travelled while the ship is under way and not under way should be included in the aggregated data of distance travelled for the calendar year; and"

APPENDIX 4 STANDARDIZED DATA-REPORTING FORMAT FOR THE DATA-COLLECTION SYSTEM AND OPERATIONAL CARBON INTENSITY TO THE ADMINISTRATION

Fuel oil consumption data

3 Under the existing row on "Total distance travelled (nm)", new rows are added as follows:

"

While the ship is under way	
While the ship is not under way	

"

***

ANNEX 16

RESOLUTION MEPC.414(84)
(adopted on 1 May 2026)

2026 GUIDELINES FOR TEST-BED AND ONBOARD MEASUREMENTS OF METHANE (CH_4) AND/OR NITROUS OXIDE (N_2O) EMISSIONS FROM MARINE DIESEL ENGINES

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 conferred upon it by international conventions for the prevention and control of marine pollution from ships,

RECALLING ALSO that, at its eightieth session, it adopted, by resolution MEPC.377(80), the *2023 IMO Strategy on reduction of GHG emissions from ships* (2023 IMO GHG Strategy) setting out the levels of ambition for the international shipping sector in reducing GHG emissions,

NOTING that the 2023 IMO GHG Strategy provides that in order to support the global availability and uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources, the Organization may consider and analyse measures to address emissions of methane (CH_4) and nitrous oxide (N_2O),

RECALLING that, at its eighty-third session, it adopted, by resolution MEPC.402(83), the *Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines*,

HAVING CONSIDERED, at its eighty-fourth session, draft revised guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines,

1 ADOPTS the *2026 Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines*, as set out in the annex to the present resolution;

2 INVITES Member States to encourage shipowners, ship operators, shipbuilders, marine diesel engine manufacturers and any other interested groups to voluntarily apply these Guidelines when undertaking measurements, calculation and reporting of CH_4 and/or N_2O emission values from marine diesel engines;

3 ALSO INVITES Member States to share data gathered in applying these Guidelines to future sessions of the Committee;

4 AGREES to keep these Guidelines under review in light of the experience gained with their implementation.

5 AGREES that these Guidelines supersede the *Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* adopted by resolution MEPC.402(83).

ANNEX

2026 GUIDELINES FOR TEST-BED AND ONBOARD MEASUREMENTS OF METHANE (CH_4) AND/OR NITROUS OXIDE (N_2O) EMISSIONS FROM MARINE DIESEL ENGINES

1 Introduction

1.1 The purpose of these Guidelines is to specify the protocol for test-bed and onboard measurements, calculation and reporting of methane (CH_4) and/or nitrous oxide (N_2O) emission values from marine diesel engines, as well as documentation and verification of CH_4 and/or N_2O emission values.

1.2 For the purpose of these Guidelines, "methane-containing fuel" means natural gas, bio-methane, e-methane, and mixtures of these fuels.

1.3 The measurements, calculations and reporting for CH_4 and/or N_2O emission values should be carried out in accordance with the NO_x Technical Code 2008 as amended, (NTC 2008) other than as specifically provided for in the protocol set out in appendix 1 of these Guidelines. All references in appendix 1 are to NTC 2008.

1.4 For onboard measurements, the protocol set out in appendix 1 may be accepted for an Individual Engine or for an Engine Group represented by the Parent Engine. It should not be accepted for an Engine Family without further justifications. For test-bed measurements, the protocol may also be accepted for an Engine Family.[1]

2 Information to be included in the CH_4 and/or N_2O file

2.1 The applicant for the establishment of the emission values should prepare a CH_4 and/or N_2O file that should contain the following information:

.1 details of the engine as tested should include but are not limited to:

.1 model and designation;

.2 rated power and rated speed;

.3 listing of NO_x critical components as fitted and settings / operating values as applied including, for CH_4, NO_x certified maximum liquid-to-gas fuel ratios across load range; and

.4 other components and settings / operating values which affect CH_4 and/or N_2O emissions;

.2 details, including drawings of exhaust system, showing sampling position(s);

1 The composition of an Engine Family or an Engine Group as defined in NTC 2008 is set solely by factors affecting NO_x emissions; those cannot be assumed to be equally applicable to CH_4 and/or N_2O emissions. In some instances, such as liquid-to-gas fuel ratio, the requirements for highest NO_x will tend to result in lowest CH_4.

.3 where $C_{slip\text{-}CH4}$ is reported, crankcase emissions should only be included for trunk piston engines without closed crankcase ventilation. Details of how that was determined should be provided. If crankcase emissions are not measured, an emission value based on technical justification and relevant emission data may be used. If the manufacturer does not have such data, an emission value of 1 g/kWh should be used;

.4 a copy of the relevant engine test data, as given in appendix 2 of these Guidelines and any additional data to fully define the engine performance and enable calculation of the gaseous emissions of CH_4 and/or N_2O. For test-bed measurements, this information can also be provided in the test report as referred to in section 5.10 of the NTC 2008;

.5 where a CH_4 and/or N_2O reducing device or system is used, the CH_4 and/or N_2O file should contain documentation on the emission abatement device, giving details of its intended purpose, manner of operation, critical components and settings / operating values together with information on any consumables necessary for its operation. Where exhaust gas samples are to be drawn from both before and after the device, details of analyser changeover arrangements and sequencing should be given if only one set of analysers is to be used.

3 The use of existing measurement data

3.1 Existing measurements conducted prior to the adoption of these Guidelines may be accepted, provided that they were carried out in accordance with the NTC 2008. In such cases, the provisions applicable exclusively to onboard measurements, as set out in these Guidelines, may have been applied.

3.2 If existing measurements for CH_4 have not been conducted, emission values for total hydrocarbons (HC), as set out in the engine's NO_x technical file, may be used as a proxy. The CH_4 emission values may be established based on the weighted percentage of methane in the gas fuel. Where the fuel composition is not available in the engine's NO_x technical file, total HC emissions should be assumed to consist of 100% CH_4.

3.3 If the existing measurements based on the E2 test cycle do not contain emission values for the 10% load point or the lowest mode point at which gas fuel would be used, data from the D2 test cycle of the same parent engine may be considered representative provided that the same parent engine is certified for both D2 and E2 cycles and operates with identical settings.

4 Verification of the CH_4 and/or N_2O emission values

4.1 In order to confirm that the emission values have been established in accordance with these Guidelines, the CH_4 and/or N_2O file should be submitted to the Administration for verification.

4.2 On receipt of the CH_4 and/or N_2O file from the applicant and satisfactory completion of the verification, a Statement of emission values for CH_4 and/or N_2O should be issued by the Administration. The form of Statement of emission values for CH_4 and/or N_2O is set out in appendix 3 of these Guidelines.

APPENDIX 1

PROTOCOL FOR TEST-BED AND ONBOARD MEASUREMENTS OF CH_4 AND/OR N_2O EMISSIONS FROM MARINE DIESEL ENGINES BASED ON THE NO_x TECHNICAL CODE 2008

Explanatory note:
This protocol does not amend mandatory provisions in NTC 2008. Measurements, calculations and reporting of CH_4 and/or N_2O emission values should be carried out in accordance with NTC 2008, other than as specifically provided for in the protocol.

<table>
<tr><th>Paragraph of NO_x Technical Code 2008</th><th>Addition to NTC 2008</th></tr>
<tr><td colspan="2">Abbreviations, subscripts and symbols</td></tr>
<tr><td></td><td>In table 1, the definitions of N_2O and NMHC are added as follows:
<table>
<tr><th>Symbol</th><th>Definition</th></tr>
<tr><td>N_2O</td><td>Nitrous oxide</td></tr>
<tr><td>NMHC</td><td>Non-methane hydrocarbons</td></tr>
</table></td></tr>
<tr><td></td><td>In table 2, abbreviations for FTIR, NDUV, NMC are added as follows:
<table>
<tr><th>Symbol</th><th>Definition</th></tr>
<tr><td>FTIR</td><td>Fourier transform infrared (analyser)</td></tr>
<tr><td>NDUV</td><td>Non-dispersive ultraviolet (analyser)</td></tr>
<tr><td>NMC</td><td>Non-methane cutter</td></tr>
</table>
Note: NMC = flame ionization detector (FID) with non-methane cutter</td></tr>
<tr><td></td><td>In table 3, symbols and terms for C_{fCH4}, C_{fN2O} and $C_{slip\text{-}CH4}$ are added as follows:
<table>
<tr><th>Symbol</th><th>Term</th></tr>
<tr><td>C_{fCH4}</td><td>g CH_4 / g fuel[2] (applicable to liquid fuels and non-methane gas fuels)</td></tr>
<tr><td>C_{fN2O}</td><td>g N_2O / g total fuel (applies to both gas and liquid fuels)</td></tr>
<tr><td>$C_{slip\text{-}CH4}$</td><td>% (of the mass of the methane-containing fuel used by the energy converter), corrected to reference gas composition (applicable to methane-containing fuels, excluding pilot fuel[3])</td></tr>
</table></td></tr>
</table>

[2] For methane containing fuels, the $C_{slip\text{-}CH4}$ covers the role of C_{fCH4}, so C_{fCH4} is set to zero for these fuels. For the purpose of these Guidelines, non-methane gas fuels should be regarded as liquid fuels.

[3] CH_4 emissions from the pilot fuel are accounted for in the $C_{slip\text{-}CH4}$ value. For pilot fuel used in a dual fuel engine, CH_4 emissions should not therefore be determined separately on the basis of the quantity of pilot fuel used.

	Note: $C_{slip\text{-}CH4}$ is a factor accounting for CH_4 (expressed in % of mass of methane containing fuel consumed in the energy converter) which is emitted from the energy converter (including fuel from combustion chamber/oxidation process and from crankcase, as appropriate).
Chapter 3	
3.2 Test cycles and weighting factors to be applied	For the test cycles E2 and E3, the specific emission at the 10% mode point or the lowest mode point at which gas fuel would be used should be measured and reported in addition to the existing mode points. **For onboard measurements only**: In setting the load points of the test cycle to be followed the provisions of 6.4.6.7 should apply. In the case of the 100% load point this should, subject to the engine emission test plan, be allowed to be no lower than 85% of rated power. If that value cannot be achieved, then the test should be deferred to such time that at least that power level can be achieved. The test cycle 100% power weighting factor under 3.2 should be applied irrespective of the actual power developed at that load point.
Chapter 5	
5.2.5.3 Positioning of abatement device or system	Requirements do not necessarily apply to CH_4 and/or N_2O abatement device or system. The installation requirements of the device should be respected and provided in the CH_4 and/or N_2O file.
5.6.1 Permissible deviations of instruments for engine-related parameters and other essential parameters	**For onboard measurements only**: Engine performance and ambient condition monitoring equipment requirements should be in accordance with the requirements of 6.4.5.1.
5.9.2	CH_4 and/or N_2O should be added to the list of main exhaust components. In the case of CH_4, this means CH_4 as reported by the measurement device before correction for NMC efficiency.
5.9.3.2 Exhaust gas temperature at sample probe for HC	For the measurement of CH_4 and/or N_2O, there are no minimum temperature requirements.
5.9.6.2 Test sequence	**For onboard measurements only**: At each load point of a test cycle the provisions of 6.4.6.8 should apply rather than those of 5.9.6.2. In the case of the E3 test cycle, if the actual propeller curve differs from the E3 curve, the load point used should be set using the measured engine power.
5.11 Data evaluation for gaseous emissions	In addition to the concentrations for the species to be determined as specified by 5.11 of NTC 2008, the concentrations of CH_4 and/or N_2O are to be determined. The averaged results are to be given in ppm.

Where the NMC methane efficiency is not 0% and/or the NMC ethane efficiency is not 100% the CH_4 concentration to be used in equation 18a is calculated as follows:

The concentration of CH_4 should be calculated as follows for propane as calibration gas, bypassing NMC:

$$c_{CH4} = \frac{c_{HC(wCutter)} - c_{HC(w/oCutter)} \; * (1 - E_e)}{f_{RF\ CH4(HC-FID)} * (E_e - E_m)}$$

The concentration of CH_4 should be calculated as follows for methane as calibration gas, passing through the NMC:

$$c_{CH4} = \frac{c_{HC(wCutter)} * \; f_{RF\ CH4(HC-FID)} * \; (1 - E_m) \; - \; c_{HC(w/oCutter)} \; * (1 - E_e)}{f_{RF\ CH4(HC-FID)} * (E_e - E_m)}$$

where:

$c_{HC(wCutter)}$ is the HC concentration with the sample gas flowing through the NMC;

$c_{HC(w/oCutter)}$ is the HC concentration with the sample gas bypassing the NMC;

$f_{RF\ CH4(HC-FID)}$ is the methane response factor;

E_m is the methane efficiency as determined per appendix IV, 8.5.1 ; and

E_e is the ethane efficiency as determined per appendix IV, 8.5.2.

5.12.5.1 Calculation of the emission mass flow rates

For the calculation of the emission mass flow rates in 5.12.5.1, u_{gas} values for N_2O and/or CH_4 should be calculated using table 5 as extended:

Gas		HC	CH_4	N_2O
ρ_{gas} kg/m^3		*	0.716	1.9631
	ρ_e†	Coefficient u_{gas}‡		
Liquid fuel**	1.2943	0.000479	0.000553	0.001517
Rapeseed Methyl Ester	1.2950	0.000536	0.000553	0.001516
Methanol	1.2610	0.001133	0.000568	0.001557

Ethanol	1.2757	0.000805	0.000561	0.001539
Natural gas	1.2661	0.000558*	0.000565	0.001551
Propane	1.2805	0.000512	0.000559	0.001533
Butane	1.2832	0.000505	0.000558	0.001530

* In the case of HC emissions when using natural gas as the fuel, the given u_{gas} value of 0.000558 should be used for NMHC on the basis of CH2.93. For total HC, the u_{gas} of CH_4 should be used.

5.12.5.2

The CH_4 and/or N_2O concentration to be entered into equation 18a is the value from 5.11 on a wet basis.

5.12.6 Calculation of the specific emission

Calculate C_{fCH4} (g/g fuel and g/kWh), C_{fN2O} (g/g fuel and g/kWh) and $C_{slip\text{-}CH4}$ (% of the mass of the methane containing fuel used by the engine) for each load point where emissions are measured.

For liquid fuels and non-methane gas fuels:

$$C_{fgas} = q_{mgas} / \textit{fuel flow}$$

where:

q_{mgas} (g/h): mass flow of CH_4/N_2O as measured (from combustion);

fuel flow (g/h): total mass flow of fuels applicable to C_{fCH4} (i.e. the total flow of liquid fuels and/or non-methane gas fuels).

For methane-containing fuels:

$$C_{slip\text{-}CH4,act} = (q_{mCH4} / \textit{fuel flow}) \cdot 100$$

where:

q_{mCH4} (g/h): mass flow of CH_4 as measured (unburned slip);

fuel flow (g/h): total mass flow of methane containing fuels (excluding pilot fuels).

Calculate the average weighed emissions

$$C_{fgas} = \sum\_i{=}1...n\ (q_{mgas} \cdot W_{Fi}) / sum\_i{=}1..n\ (q_{fuel,i} \cdot W_{Fi})$$

With $q_{fuel,i}$ being the fuel flow at each mode point.

$$C_{slip\text{-}CH4,\ act} = \Sigma\ i{=}1...n\ (\ q_{mCH4,\ act} \cdot W_{Fi}) / 10 / \Sigma\ \_i{=}1..n\ (q_{fuel,i} \cdot W_{Fi})$$

$$C_{slip-CH4} = C_{slip-CH4,act} \times \frac{x_{CH4ref}}{x_{CH4act}}$$

	where: $C_{slip-CH4,act}$ = C_{slip} value calculated with actual fuel gas composition during testing X_{CH4ref} = mass fraction of methane in the reference fuel (w-%) X_{CH4act} = mass fraction of methane in the test fuel (w-%) Reference fuel methane fraction 84.6 w-% (92.2 mol-%) as in the mathematical average of LNG compositions in ISO 23306:2020. q_{mgas} (g/h): see section 5.12.5.2 of the NTC 2008, equation 18a Fuel flow (g/h) as measured.
Appendix III	
	Section 1.1 CH_4 and/or N_2O are added to the list of components included in the exhaust gas analysis system.
	Figure 1 • For arrangements of exhaust gas analysis measurement systems for the measurement of CH_4, refer to ISO 8178-1 section 7.4.4. • Alternatively, the arrangements described in 3.6 below should be accepted. • NMC and N_2O analyser should be arranged, installed and operated in accordance with the respective manufacturer's recommendations.
	Section 1.2 Analysers for CH_4 and N_2O: see section 3
	Section 3 **3.6 Methane (CH_4) analysis** The reference method for CH_4 should be FID + NMC. Alternatively, a dual FID set-up as described in appendix 4 to these guidelines should be accepted. Other principles / systems should be accepted if proven against FID+NMC with exhaust gases of the compositions to be measured. It should be ensured that the HC / CH_4 analyser(s) to be used have duly calibrated ranges for the respective concentrations to be measured. The NMC should have the capacity to handle the expected CH_4 and NMHC concentrations. **3.7 Nitrous oxide (N_2O) analysis** An FTIR analyser, an NDIR (non-dispersive infrared) analyser, laser infrared analyser or NDUV analyser may be used in accordance with the instrument supplier's instructions.

	Note: According to sections 5.4.2 and 5.4.3 of the NTC 2008, other systems or analysers may, subject to the approval of the Administration, be accepted if they yield equivalent results to that of the equipment referenced.
Appendix IV	**Calibration of the analytical and measurement instruments**
	Requirements of table 1 or table 3 regarding fuel measurement device apply separately to both liquid fuel meter and gas fuel meter.
	In addition to the calibration procedures of appendix IV of the NTC 2008, relevant parts of ISO 8178-1 for calibration of CH_4 and/or N_2O measurement instruments should be applied. FID should be calibrated with NMC bypassed with NMC efficiencies E_e and E_m determined separately.
	Section 2 "C_2H_6 and purified synthetic air" is added to 2.2.1.5. A new sub-paragraph "2.2.1.6 N_2O and purified nitrogen" is added after the existing 2.2.1.5.
	Section 5 N_2O is added to the list of analysers in the first sentence of 5.4.2.
8.4	For measurement of N_2O, a new section 8.4 applies
8.4.1	The interference should be checked prior to first use of an analyser and after major servicing or updating of software.
8.4.2	In those cases where the analyser applies compensation algorithms which use as inputs the concentrations of other measured gases those measurements should be undertaken concurrently with this verification check.
8.4.3	For NDIR - The potential for cross interferences effects of CO, CO_2, H_2O, CH_4 and SO_2 as applicable should be checked.
8.4.3.1	Apart from H_2O the interference species are dependent on the selected N_2O absorption band used by the device which should be known. From that knowledge good engineering judgement should be used to determine the interference gases to be used based on those which may be expected to be present in the exhaust gases to be measured.
8.4.4	For FTIR or Laser Infrared – The interference gases depend on the selected N_2O absorption band used by the device which should be known. Based on that knowledge good engineering judgement should be used to determine the interference gases to be used.
8.4.5	The combined effect of the interference gases should not be more 1.0 μmol/mol.

8.4.6	Verification procedure: .1 The concentrations of the interference span gases as identified from 8.4.3 or 8.4.4 should be at least as high as the maximum values to be encountered in service. Those interference gases may be presented in the form of a multi-component span gas. .2 The N_2O analyser is started, operated, zeroed and spanned as in service. .3 Humified interference test gas should be fed into the analyser. That test gas should be generated by bubbling the multi-component span gas through distilled H_2O in a sealed container. If the sample is not treated by a dryer the container temperature should be controlled to generate a H_2O concentration at least as high as the expected maximum when in service. If the sample is treated by a dryer the container temperature should be controlled to generate a H_2O concentration at least as high as the expected maximum based on the dryer outlet temperature when in service. .4 The water mole fraction of the test gas should be determined from measurements taken as close as possible to the analyser inlet. Those measurements may be dew point and absolute pressure. .5 Condensation in the piping leading from the container generating the humidified test gas to the analyser should be minimized by maintaining an adequate minimum temperature. .6 Following stabilization, the analyser output should be recorded for 30 s. The arithmetic mean response over that period should be compared with the limit in 8.4.5.
8.4.6.1	As an alternative to the multi-component span gas in 8.4.6 individual span gases may be run separately. Where an interference gas concentration is higher than that to be measured in service the determined interference value should be scaled down by the ratio of in-service maximum / span concentration. Where the H_2O concentration is below that to be measured in service, but not below 0.025 mol/mol H_2O content, the determined interference may be scaled up by the ratio of maximum in-service value / the value used. The sum of the individual interferences should be compared with the limit in 8.4.5.
8.4.7	An interference verification check report documenting the procedure as followed, including the rational for the interference gases used and their concentrations, and the outcomes of that procedure is to be prepared and should be available as may be required.

8.4.8	Alternative approaches to the verification of N_2O analyser interference may be acceptable. Where so used the justification for the approach taken should be included in the report as required by 8.4.7. Irrespective of the procedure followed the limit given by 8.4.5 remains applicable.
8.5	**Efficiency of the non-methane cutter (NMC)**
	The NMC is used for the removal of the non-methane hydrocarbons from the sample gas by oxidizing all hydrocarbons except CH_4. Ideally, the conversion rate for CH_4 is 0% and for the other hydrocarbons, as represented by ethane, is 100%. The efficiency of the NMC may be checked as part of the pretest verification procedures under 6.1 and again on completion of the measurement exercise (at the time of rechecking the analysers in accordance with 5.9.9 of NTC 2008) with the average of the two *Em* and *Ee* values so obtained being used to correct the measured CH_4 concentrations. In any case, the efficiency verification should be done within 185 days before testing, and after major maintenance. With the agreement of the Administration, alternative approaches to the assessment of NMC efficiency may be accepted. Methane efficiency ≤ 15% Ethane efficiency ≥ 98%
8.5.1	**NMC methane efficiency**
	Methane calibration gas at a concentration typical of that to be measured is flowed through the FID analyser with and without the NMC bypassed. The methane efficiency, *Em*, is determined as: $$E_m = 1 - \frac{c_M\ (wCutter)}{c_M\ (w/oCutter)}$$ Where: c_M *(wCutter)* HC concentration with CH_4 flowing through the NMC (ppmC1) c_M *(w/oCutter)* HC concentration with CH_4 bypassing NMC (ppmC1)

8.5.2	**NMC ethane efficiency**
	Ethane calibration gas at a concentration typical of the expected non-methane hydrocarbon concentration to be measured is flowed through the FID analyser with and without the NMC bypassed. The ethane efficiency, *Ee*, is determined as: $$E_e = 1 - \frac{c_E\ (wCutter)}{c_E\ (w/oCutter)}$$ Where: c_E *(wCutter)* HC concentration with C_2H_6 flowing through the NMC (ppmC1) c_E *(w/oCutter)* HC concentration with C_2H_6 bypassing NMC (ppmC1)

APPENDIX 2

ENGINE TEST REPORT AND TEST DATA – CH_4 AND/OR N_2O CALCULATIONS

Engine	
Manufacturer	
Engine type	
Emission abatement device	
Engine family or Engine group identification	
Serial number	
Rated power	
Rated speed	

Emissions test results:					
Test cycle					
C_{fCH4} weighted					g/g fuel
$C_{slip\text{-}CH4}$ weighted					% (of the mass of the methane containing fuel used by the engine)
N_2O (weighted)					g/g total fuel
Test identification					
Date/time					
Test site					
Test number					
Company					
Date and place of report					
Signature					

Measurement equipment					
	Manufacturer	Model	Measurement ranges	Calibration	
				Span gas conc.	Deviation of calibration
Analyser					
HC / CH_4 Analyser*			ppm		%
N_2O Analyser			ppm		%
CO Analyser			ppm		%
CO_2 Analyser			%		%
O_2 Analyser			%		%
Speed			rpm		%

Torque			Nm		%
Power, if applicable			kW		%
Fuel flow-liquid					%
Fuel flow-gas					%
Air flow					%
Exhaust flow					%
Temperatures					
Charge air coolant inlet			ºC		ºC
Exhaust gas			ºC		ºC
Inlet air			ºC		ºC
Charge air			ºC		ºC
Fuel-liquid			ºC		ºC
Fuel-gas			ºC		ºC
Pressures					
Exhaust gas			kPa		kPa
Charge air			kPa		kPa
Atmospheric			kPa		kPa
Vapour pressure					
Intake air			kPa		%
Humidity					
Intake air			%		%

* For FID+NMC

Make and model of NMC		
	Before measurement	After measurement
NMC CH_4 gas concentration	ppmC	ppmC
HC with CH_4 through NMC	ppmC	ppmC
HC with CH_4 bypassing NMC	ppmC	ppmC
NMC methane efficiency *Em*		
NMC C_2H_6 gas concentration	ppmC	ppmC
HC with C_2H_6 through NMC	ppmC	ppmC
HC with C_2H_6 bypassing NMC	ppmC	ppmC
NMC ethane efficiency *Ee*		

Liquid fuel characteristics

Fuel type				
Fuel properties:			**Fuel elemental analysis:**	
Density	ISO 3675	kg/m^3	Carbon	% m/m
Viscosity	ISO 3104	mm^2/s	Hydrogen	% m/m
Water	ISO 3733	% V/V	Nitrogen	% m/m
Lower heating value/Hu		MJ/kg	Oxygen	% m/m
			Sulphur	% m/m

Gas fuel characteristics

Fuel type:				
Fuel properties			**Fuel elemental analysis**	
Methane number	EN16726:2015		Carbon	% m/m
Lower heating value		MJ/kg	Hydrogen	% m/m
Boiling point		°C	Nitrogen	% m/m
Density at boiling point		kg/m^3	Oxygen	% m/m
Pressure at boiling point		Bar (abs)	Sulphur	% m/m
			Methane, CH_4	mol%
			Ethane, C_2H_6	mol%
			Propane, C_3H_8	mol%
			Isobutane, i C_4H_{10}	mol%
			N-Butane, n C_4H_{10}	mol%
			Pentane, C_5H_{12}	mol%
			C_6+	mol%
			CO_2	mol%

Gaseous emissions data

Mode	1	2	3	4	5	6	7	8	9	10
Power/Torque (%)										
Speed (%)										
Time at beginning of mode										

Gaseous emissions data:										
Sampling position										
HC concentration (ppmC)										
CH_4 concentration (ppmC)* recorded#										
CH_4 concentration (ppmC)* - corrected#										
N_2O concentration (ppm)*										
CO concentration (ppm)										
CO_2 concentration (%)										
O_2 concentration (%)										
CH_4 mass flow (kg/h)*#										
N_2O mass flow (kg/h)*										
CO mass flow (kg/h)										
CO_2 mass flow (kg/h)										
O_2 mass flow (kg/h)										
CH_4 (g/g)*#										
CH_4 (g/kWh)* #										
N_2O (g/g)*										
N_2O (g/kWh)*										

* As applicable.

\# As applicable to either liquid or gas fuel.

Engine parameters to be measured and recorded

Mode	1	2	3	4	5	6	7	8	9	10
Power/Torque (%)										
Speed (%)										
Time at beginning of mode										

Engine data										
Speed (rpm)										
Power (kW)										
Mean effective pressure (kPa)										
Fuel rack/gas admission duration** (mm/sec)										
Liquid-to-gas fuel ratio (on mass basis)										
Liquid Fuel flow (kg/h or m^3/h*)										
Gas Fuel flow (kg/h)										
Exhaust flow (q_{mew}) (kg/h)										
Exhaust temperature at the sampling point (°C)										
Charge air coolant temperature in (°C)										
Charge air coolant temperature out (°C)										
Charge air temperature (°C)										
Charge air reference temperature (°C)										
Charge air pressure (kPa)										
Fuel-liquid temperature before the engine (°C)										
Fuel-gas temperature before the engine (°C)										

Ambient data										
Atmospheric pressure (kPa)										
Intake air temperature (°C)										
Intake air humidity (g/kg)										
Relative humidity (RH) of intake air* %										
Air temperature at RH sensor* (°C)										
Dry bulb temperature of intake air* (°C)										
Wet bulb temperature of intake air* (°C)										

* As applicable.
** Only for engines to be tested with gas fuel.

Abatement device:

The report should state whether reported data before or after device- hence the gaseous emission data page will need to be repeated, if both are to be given.

Additionally, if both before and after data given, the analyser data should, if relevant, be repeated to cover all analysers used.

For each mode point, the following device data should additionally be recorded: Settings, Operating values and Consumption (specified rates).

APPENDIX 3

FORM OF STATEMENT OF EMISSION VALUES FOR METHANE (CH_4) AND/OR NITROUS OXIDE (N_2O)

Issued in accordance with the *2026 Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* (resolution MEPC.414(84)) under the authority of the Government of:

…………………………………………………………………………………………………
(full designation of the country)

by..
(full designation of the competent person or organization authorized)

Particulars of applicant

Name of applicant………………………………………………………………………………

THIS IS TO DECLARE THAT:

1 the applicant has submitted to this Administration the information recommended by the *2026 Guidelines for test-bed and onboard measurements of CH_4 and/or N_2O emissions from marine diesel engines* (resolution MEPC.414(84));

2 the emission value(s) have been established in accordance with the *2026 Guidelines for test-bed and onboard measurements of CH_4 and/or N_2O emissions from marine diesel engines* (resolution MEPC.414(84));

3 the engine weighted verified emissions value(s) are as follows:

1	Engine manufacturer and model	
2	Engine serial number	
3	Abatement device manufacturer and model	
4	Device serial number	
5	Use (applicable test cycle(s) – NTC 3.2)	
6	C_{fCH4} (g/g fuel)*	
7	$C_{slip\text{-}CH4}$ % (of the mass of the methane containing fuel used by the engine)*	
8	C_{fN2O} (g/g fuel)*	

* Include as appropriate

Issued at……………………………………………………………………………………...
(place of issue of the Statement)

(dd/mm/yyyy): .... *(date of issue)*

.... *(signature of duly authorized official issuing the Statement)*

(seal or stamp of the authority, as appropriate)

APPENDIX 4

DUAL FLAME IONIZATION DETECTOR (FID) SET-UP TO MEASURE METHANE (CH_4)

1 Measuring set-up

1 A dual FID set-up to measure methane (CH_4) requires two FID analysers which should be compliant with the specifications of the NO_x Technical Code 2008 (NTC 2008), and one NMC equipment which should be compliant with the requirements of appendix 1 of these guidelines. The NMC should have a bypass function to enable the testing of the efficiency of the NMC. The bypass function is required only for testing the efficiency of the NMC. The sampling system also should be compliant with the NTC 2008. The analyser set-up is shown in figure 1:

.1 One FID connected downstream of the NMC (called the NMC-FID); and

.2 One FID connected to the sample system in parallel, without an NMC (called the HC-FID)

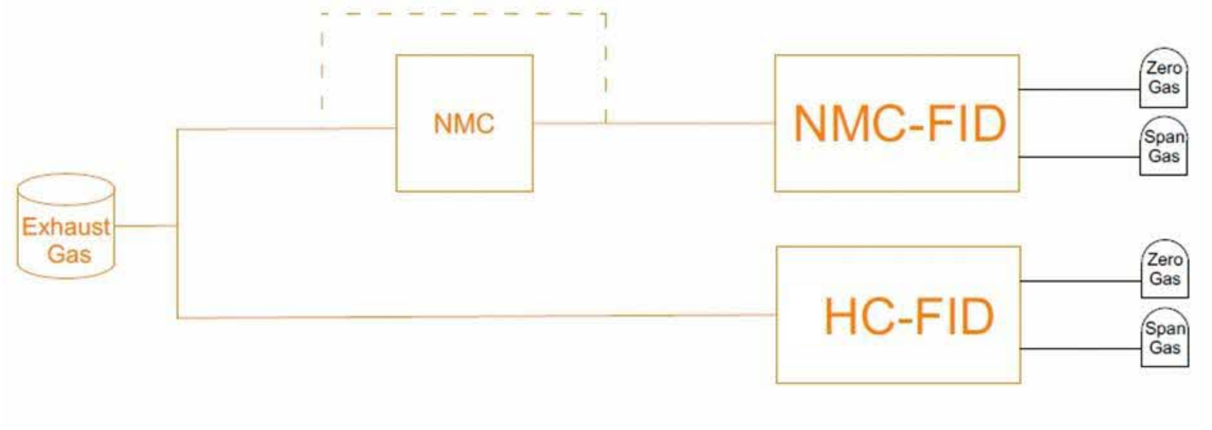


Figure 1 – *Dual FID set-up for measurement of methane (CH_4)*

2 The FIDs and the NMC should be operated according to the manufacturer's specification.

2 Gases and calibration

3 The following gases should be available for the establishment of a calibration curve ,daily adjustments and span checks in accordance with 5.9.9 of the NTC 2008:

.1 CH_4 span gas, at a concentration of at least 80% of the NMC-FID measurement range;

.2 C_3H_8 span gas, at a concentration of at least 80% of the HC-FID measurement range (calculated on a C1 basis, according to the NTC 2008);

.3 a zero gas, that can be either purified nitrogen or purified synthetic air; and

.4 hydrogen/helium mixture and purified synthetic air for the operation of the FIDs.

4 All aforementioned gases should be compliant with section 2 of appendix IV of the NTC 2008.

5 Both FIDs should be zeroed with the zero gas. The linearity check, establishment of calibration curve and span calibration of the HC-FID and the NMC-FID should be done with the C_3H_8 and CH_4 gas mixtures respectively. The NMC should not be bypassed during this check.

3 Efficiency of the NMC and CH_4 response factor

3.1 CH_4 response factor

6 The CH_4 response factor RF_{CH4} is calculated only for the HC-FID. The procedure for determining the response factor should be done according to section 8.2 of appendix IV of the NTC 2008. According to the NTC 2008, the test should be performed when the analyser is first commissioned and after major service has taken place.

7 The CH_4 response factor for the NMC-FID is set to 1.

3.2 Efficiency of NMC

8 This section details the procedure for determining the Ethane efficiency *Ee* and Methane efficiency *Em*, as described in section 8.5 of appendix 1 to these Guidelines. The procedure described below is performed on the NMC-FID only.

.1 A zero gas (as mentioned in section 2) and gas mixtures containing CH_4 and C_2H_6 at a concentration above 80% of the analyser's measuring range are prepared, as well as a hydrogen/helium mixture and purified synthetic air for the operation of the FID. All gases need to be compliant with section 2 of appendix IV of the NTC 2008;

.2 The NMC-FID is warmed up and operated according to the instructions of the manufacturer;

.3 The NMC-FID is calibrated with zero gas and CH_4 gas, through the NMC;

.4 C_2H_6 gas is introduced to the analyser, through the NMC and the concentration is recorded as c_{C2H6}(wCutter);

.5 C_2H_6 gas is introduced to the analyser, bypassing the NMC and the concentration is recorded as c_{C2H6}(w/oCutter);

.6 CH_4 gas is introduced to the analyser, through the NMC and the concentration is recorded as c_{CH4}(wCutter);

.7 CH_4 gas is introduced to the analyser, bypassing the NMC and the concentration is recorded as c_{CH4}(w/oCutter); and

.8 The Ethane efficiency (*Ee*) and Methane efficiency (*Em*) are calculated as follows:

$$E_e = 1 - \frac{c_{C_2H_6}(wCutter)}{c_{C_2H_6}(w/oCutter)} \qquad \text{(eqn. 1)}$$

$$E_m = 1 - \frac{c_{CH_4}(wCutter)}{c_{CH_4}(w/oCutter)} \qquad \text{(eqn. 2)}$$

9 In order comply with section 8.5 of appendix 1 to these Guidelines the achieved efficiencies should be: *Ee* ≥ 98% and *Em* ≤ 15%.

10 It is important to note that the value of *Em* calculated based on (eqn. 2) is only relevant for the NMC efficiency check. For the calculations in section 4, *Em* is set to 0.

4 Calculation of corrected CH_4 concentration

11 The corrected CH_4 concentration (c_{CH4cor}) can be calculated with the following formula:

$$c_{CH4_{cor}} = \frac{c_{CH4} - c_{HC}(1-E_e)}{1-((1-E_e)*RF_{CH4})} \qquad \text{(eqn. 3)}$$

where:

$c_{CH4_{cor}}$: corrected CH_4 concentration (ppm)
c_{CH4}: CH_4 concentration (ppm) as measured with the NMC-FID
c_{HC}*:* HC concentration (ppmC1) as measured with the HC-FID
E_e*:* Ethane efficiency (see section 3.2)
RF_{CH4}: CH_4 response factor of the HC-FID (see section 3.1)

12 The corrected CH_4 concentration $c_{CH4_{cor}}$ should be used to determine the methane mass flow rate as explained in section 5.12.5 of appendix 1 to these Guidelines.

***

ANNEX 17

RESOLUTION MEPC.415(84)
(adopted on 1 May 2026)

GUIDELINES FOR ENGINE LOAD MONITORING (ELM) AND CALCULATION OF EMISSION VALUES

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 conferred upon it by international conventions for the prevention and control of marine pollution from ships,

RECALLING ALSO that, at its eightieth session, it adopted, by resolution MEPC.377(80), the *2023 IMO Strategy on reduction of GHG emissions from ships* (2023 IMO GHG Strategy) setting out the levels of ambition for the international shipping sector in reducing GHG emissions,

NOTING that the 2023 IMO GHG Strategy provides that in order to support the global availability and uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources, the Organization may consider and analyse measures to address emissions of methane (CH_4) and nitrous oxide (N_2O),

HAVING CONSIDERED, at its eighty-fourth session, draft guidelines for engine load monitoring (ELM) and calculation of emission values,

1 ADOPTS the *Guidelines for engine load monitoring (ELM) and calculation of emission values*, as set out in the annex to the present resolution;

2 INVITES Member States to encourage shipowners, ship operators, shipbuilders, marine diesel engine manufacturers and any other interested groups to voluntarily apply these Guidelines when undertaking measurements, calculation and reporting of CH_4 and/or N_2O emission values from marine diesel engines;

3 ALSO INVITES Member States to share data gathered in applying these Guidelines to future sessions of the Committee;

4 AGREES to keep these Guidelines under review in light of the experience gained with their implementation.

ANNEX

GUIDELINES FOR ENGINE LOAD MONITORING (ELM) AND CALCULATION OF EMISSION VALUES

1 Introduction

1.1 The purpose of this procedure is to specify the method for engine load monitoring (ELM) to establish factors that reflect the actual operation of a marine diesel engine, and for the calculation of emission values.

1.2 The ELM can be used to monitor actual engine load during operation instead of the pre-defined weighting factors as described in section 3.2 of the NO_x Technical Code 2008 (NTC 2008), as amended, and to be used in combination with verified CH_4/N_2O emission measurements to arrive at more representative emission values.

2 Emission values at different engine loads

2.1 The emission values for the different engine loads are based on the verified CH_4 and/or N_2O emission values established in accordance with the *2026 Guidelines for test-bed and onboard measurements of methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* (resolution MEPC.414(84)). Between the measured points, the emission value is calculated by linear interpolation of the closest data points above and below the load point. For engine loads below the lowest measured load point, the emission value at the 10% load point or the lowest mode point at which gas fuel would be used should be used for the calculations. For engine loads above the highest measured load point, the emission value at the highest measured load point should be used.

3 Load monitoring

3.1 The load of each engine to which this ELM procedure is to be applied should be monitored. Load signal may be based on load measurement from the torque flange, the shaft strain gauge or calculated from the generator output, etc. In case no direct load measurement signal is available, estimated load based on e.g.: cylinder pressure, injection duration, etc. may also be used subject to the approval of the Administration, as in paragraph 6.4.3.4 of the NTC 2008. Measurement equipment used in conjunction with this ELM procedure should meet the requirements given in tables 3 and 4 of the NTC 2008, appendix IV and be calibrated in accordance with the manufacturer's recommendations.

3.2 Engine load should be continuously monitored and recorded onto a data recording and processing device at a rate which should not be less than 0.0035 Hz. Engine load is averaged in 30-minute intervals (or other time period approved by the Administration). Zero load or liquid fuel only operation should be excluded from the averaging.

3.3 When the engine has a gas fuel flow measurement device installed, calibration of the flow meters should be specified in the data collection procedure, and the calibration and maintenance records should be included in the yearly report referred to in section 5.

4 Calculations

4.1 Emission values for corresponding engine loads are calculated from verified measurements in unit g/g fuel, $C_{slip\text{-}CH4}$ (% of the mass of the methane containing fuel used by the energy converter), or g/kWh. Calculation of yearly emission values (g/g fuel) is done by following the procedure.

Option A: If an engine has a gas fuel flow measurement device installed (example in table 2):

.1 total fuel mass (kg) is calculated during the 30-minute period (or other appropriate time period) based on the fuel flowmeter;

.2 $C_{slip\text{-}CH4}$ (%) emission factor for the load averaged over the period is calculated from the measurement data as described in section 2;

.3 CH_4 emission mass in kg during the period is calculated by multiplying the fuel mass by the $C_{slip\text{-}CH4}$ (%) emission factor; and

.4 total weighted $C_{slip\text{-}CH4}$ (%) for the year is calculated by dividing the sum of the emissions (kg) by fuel mass (kg) and multiplied by 100.

Option B: If there is no gas fuel flow measurement device installed (example in table 3):

.1 specific emission factor in g/kWh for the load averaged over the 30-minute period (or other appropriate time period) is obtained from the measurement data as described in section 2;

.2 engine load is converted to power (kW);

.3 emission mass in kg during the period is calculated by multiplying the engine power output (kW) with time (h) and the specific emission factor in g/kWh, divided by 1000; and

.4 total weighted $C_{slip\text{-}CH4}$ (%) for the year is calculated by dividing the sum of the emission (kg) by fuel mass (kg) and multiplied by 100.

Table 1: Example data set to demonstrate interpolation and calculations in tables 2 and 3

Measurement points	Load (%)	Engine power (kW)	Fuel flow LNG (kg/h)	LNG (g/kWh)	CH_4 (g/kWh)	$C_{slip\text{-}CH4}$ (%)
5	92	4,031	608	151	3.54	2.3
4	77	3,410	512	150	3.08	2.0
3	50	2,239	350	156	3.91	2.5
2	26	1,152	204	177	7.30	4.1
1	11	500	108	216	13.10	6.1

Table 2: Example of calculation if gas fuel flow data is available (for Option A)

Interval	Load (avg)	Fuel (kg)	$C_{slip\text{-}CH4}$ (%)	Emission mass (kg)
00:00-00:30	5%	34.8	6.1%	2.1
00:30-01:00	15%	66.8	5.5%	3.7
01:00-01:30	55%	190	2.4%	4.6
01:30-02:00	55%	190	2.4%	4.6
02:00-02:30	73%	244	2.1%	5.1
02:30-03:00	95%	313.5	2.3%	7.2
03:00-03:30	32%	120.25	3.7%	4.4
Total		1,159		32
Weighted $C_{slip\text{-}CH4}$ (%)				**2.7%**

Table 3: Example of calculation if gas fuel flow data is not available (for Option B)
(Engine rated power: 4,400 kW, Total fuel used during the period: 1,159 kg)

Interval	Load (avg)	Engine power (kW)	CH_4 (g/kWh)	Emission mass (kg)
00:00-00:30	5%	220	13.1	1.4
00:30-01:00	15%	660	11.6	3.8
01:00-01:30	55%	2,420	3.8	4.6
01:30-02:00	55%	2,420	3.8	4.6
02:00-02:30	73%	3,212	3.2	5.1
02:30-03:00	95%	4,180	3.5	7.4
03:00-03:30	32%	1,408	6.5	4.6
Total				32
Weighted $C_{slip\text{-}CH4}$ (%)				**2.7%**

5 Approval and verification

The monitoring method, data collection procedure and yearly load monitoring data and corresponding emission calculations should be approved by the Administration.

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ANNEX 18

RESOLUTION MEPC.416(84)
(adopted on 1 May 2026)

GUIDELINES FOR CONTINUOUS EMISSION MONITORING SYSTEMS (CEMS) USED TO QUANTIFY METHANE (CH_4) AND/OR NITROUS OXIDE (N_2O) EMISSIONS FROM MARINE DIESEL ENGINES

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 conferred upon it by international conventions for the prevention and control of marine pollution from ships,

RECALLING ALSO that, at its eightieth session, it adopted, by resolution MEPC.377(80), the *2023 IMO Strategy on reduction of GHG emissions from ships* (2023 IMO GHG Strategy) setting out the levels of ambition for the international shipping sector in reducing GHG emissions,

NOTING that the 2023 IMO GHG Strategy provides that in order to support the global availability and uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources, the Organization may consider and analyse measures to address emissions of methane (CH_4) and nitrous oxide (N_2O),

HAVING CONSIDERED, at its eighty-fourth session, draft guidelines for continuous emission monitoring systems (CEMS) used to quantify methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines,

1 ADOPTS the *Guidelines for continuous emission monitoring systems (CEMS) used to quantify methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines*, as set out in the annex to the present resolution;

2 INVITES Member States to encourage shipowners, ship operators, shipbuilders, marine diesel engine manufacturers and any other interested groups to voluntarily apply these Guidelines when undertaking measurements, calculation and reporting of CH_4 and/or N_2O emission values from marine diesel engines;

3 ALSO INVITES Member States to share data gathered in applying these Guidelines to future sessions of the Committee;

4 AGREES to keep these Guidelines under review in light of the experience gained with their implementation.

ANNEX

GUIDELINES FOR CONTINUOUS EMISSION MONITORING SYSTEMS (CEMS) USED TO QUANTIFY METHANE (CH_4) AND / OR NITROUS OXIDE (N_2O) EMISSIONS FROM MARINE DIESEL ENGINES

TABLE OF CONTENTS

1 Introduction

1.1 The purpose of these Guidelines is to provide a uniform framework for the onboard measurement and mass basis quantification of the emissions of methane (CH_4) and/or nitrous oxide (N_2O) emitted from marine diesel engines by means of a continuous emission monitoring system (CEMS). As such, these are the CH_4 or N_2O emissions to the atmosphere resulting from the particular fuel oil or, in the case of dual-fuel operation, the fuel oils and mix ratio in use at the time of measurement. Additionally, these Guidelines provide a framework for the certification of a CEMS by the Administration.

1.2 These Guidelines are divided into sections as shown in table 1.

Table 1: Section Topics

Section	Topic
2	Exhaust gas measurement and associated requirements. In addition to CH_4 and/or N_2O, this section also covers the measurement of other exhaust gas components as may be required to be measured.
3	Determination of exhaust gas flow as required in order to quantify by mass the emission rate of CH_4 and / or N_2O. Two options are provided: .1 carbon balance method. This is as given in appendix VI of the NO_x Technical Code 2008 (NTC 2008). The output from the given calculation procedures is the mass flow rate (wet) of the exhaust gas. .2 direct measurement method. This involves the measurement of the velocity of the exhaust gas. From that the volumetric exhaust gas flow rate (wet) at reference conditions is determined.
4	Intermediate and final calculations which are used to give the mass basis emission rate of CH_4 and / or N_2O over a time period referred to in these Guidelines as the reporting interval.
5	Data recording and storage requirements associated with the operation of the CEMS. It also covers the scope of the reports that the data recording device should be capable of generating.
6	Documentation requirements: For each CEMS there should be an Administration approved CEMS file detailing the system and the operating procedures to be followed together with related requirements covering the functionality of the CEMS and verification that the data generated is reliable. Additionally, a CEMS record book should be maintained on board, detailing all maintenance and servicing actions undertaken in respect of the CEMS together with details of the actions taken to resolve recorded fault conditions.
7	Certification. This covers the initial and annual surveys which should be undertaken together with the form of the CEMS Certificate to be issued.

1.3 Terms, abbreviations and definitions

1.3.1 Unless otherwise specified, the terms and definitions used in this Guideline have the same meaning as those set forth in MARPOL Annex VI, as amended, and in the NTC 2008.

1.3.2 References to the NTC 2008 mean the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, adopted by resolution MEPC.177(58), as amended.

1.3.3 Abbreviations, as given in table 2, and definitions as given in table 3, are applied in these Guidelines.

Table 2: Abbreviations

General	
CEMS	Continuous emission monitoring system
NTC 2008	NO_x Technical Code 2008, as amended
UTC	Universal Time Coordinated
Chemical compounds and related terms	
CH_4	Methane
$C_{slip\text{-}CH4}$	Methane slip as mass % of methane based gas fuel used
C_2H_6	Ethane
CO_2	Carbon dioxide
CO	Carbon monoxide
H_2O	Water vapour
HC	Hydrocarbons
N_2O	Nitrous oxide
NMHC	Non-methane hydrocarbons
Abbreviations for analysers which may be used for the measurement of emissions	
ECS	Electrochemical sensor
FTIR	Fourier transform infrared
HFID	Heated flame ionization detector
LIA	Laser infrared analyser including TDLAS
MS	Mass spectrometry
NDIR	Non-dispersive infrared
NDUV	Non-dispersive ultraviolet
NMC	Non-methane cutter
PMD	Paramagnetic detector
TDLAS	Tunable diode laser absorption spectroscopy
ZRDO	Zirconium dioxide sensor

Table 3: Definitions

Applicant	The entity which presents a CEMS for certification in accordance with these Guidelines.
Continuous emission monitoring system (CEMS)	A system for the ongoing measurement, quantification and reporting of CH_4 and / or N_2O emissions from one or more installed marine diesel engines in service. A CEMS includes the other measurement and supporting devices necessary to achieve those objectives. A CEMS may be in operation only under certain engine conditions as given by 6.1.1.3.
Extractive sampling system	System which extracts a representative sample flow from the exhaust gas stream of the monitored marine diesel engine and transfers that sample to the exhaust gas analysers which form part of a CEMS.
In situ	Exhaust gas analyser arrangements installed on the exhaust duct which directly measure one or more of the emission components of the exhaust gas stream from the monitored marine diesel engine.
Maintenance	Activities scheduled, or condition indicated, undertaken on board by ship's staff in order that the CEMS and its component parts continues to function as intended and to meet the requirements of these Guidelines. Maintenance does not include repair periods when the required CEMS output would not be available owing to malfunction or failure of a system component.
Methane based gas fuel	Fuel oils such as natural gas, biomethane or e-methane, of which the principal component is methane. Typically supplied and stored onboard in a cooled and/or pressurized condition. It does not include such as ″gas-to-liquid″ (GTL) liquid fuel oils.
Reporting interval (RI)	The time interval, as given by 5.14, in hours, over which the emission of CH_4 and / or N_2O, in kg, is reported by the CEMS. The overall emission of CH_4 and / or N_2O over a required period of CEMS operation being the sum of all the reporting interval values over that period.
Servicing	Specialist services periodically undertaken in order that the CEMS and its component parts continues to function as intended and to meet the requirements of these Guidelines.

2 Exhaust gas measurement

2.1 In situ analysers, or the sample probe of an extractive sampling system, should be located on the exhaust duct at a position such that the exhaust gas being analysed or sampled is representative of the exhaust gas as emitted to the atmosphere from the marine diesel engine being monitored. That location should be at least 0.5 m or 3 pipe diameters, whichever is the greater, upstream of the exit to atmosphere. Where HFID + NMC is used to measure CH_4, the requirements of 5.9.3.2 of the NTC 2008 should be met.

2.2 Exhaust gas streams from different engines should not be combined upstream of the in situ analysers or the extractive sampling position.

2.3 The exhaust gas should be analysed, as required, with instruments operating on the respective listed principles as given in table 4.

Table 4: Exhaust gas reference measurement methods

CH_4	HFID + NMC, FTIR, LIA
N_2O	FTIR, LIA, NDIR, NDUV
CO_2	NDIR
HC	HFID
H_2O	FTIR, MS, LIA
O_2	PMD, ECS, ZRDO[1]

2.4 Exhaust gas analysers operating on principles other than those given by 2.3 may be accepted, subject to the approval of the Administration, provided they yield equivalent results to those of analysers operating on the listed reference operating principles when used with exhaust gas of the compositions to be measured.

2.5 The analyser specifications and performance should meet the requirements of 1.6, 1.7, 1.8, 1.9 and 1.10 of appendix III of the NTC 2008.

2.6 The selected analyser range should be such that the measured emission value is within 15% - 100% of that range. Analysers should have the capability to automatically switch ranges as necessary in order to remain within 15% - 100% of the range applied according to the concentrations measured in which case the output signal to the data recording device should be duly scaled or so indicated.

2.7 As an alternative to the requirements of 2.6, the provisions of 1.4 of appendix III of the NTC 2008 may be applied as agreed to by the Administration.

[1] Where O_2 is to be measured in order to determine the dry / wet correction factor the analyser type should be ZRDO but should not be used for engines using a low-flashpoint fuel.

2.8 Analysers should be arranged, installed, operated, maintained and serviced in accordance with the respective manufacturers' recommendations in order to meet the requirements of 1.7, 1.8, 1.9 and 1.10 of appendix III of the NTC 2008, and section 5 and, if applicable, section 8 or 9 of appendix IV of the NTC 2008 together with, if relevant, appendix 3 of these Guidelines.

2.9 Where used, the HFID should be calibrated and spanned using a methane in air gas mixture of the appropriate concentration.

2.10 If used, an NMC should be arranged, installed, operated, maintained and serviced in accordance with the manufacturer's recommendations in order to meet the requirements of appendix 4 of these guidelines.

2.11 Pure, calibration and span gases, as required, should comply with section 2 of appendix IV of the NTC 2008. Declared concentrations should be traceable to national and/or international standards. Calibration and span gases should be in accordance with the analyser manufacturer's recommendations.

2.12.1 C_2H_6, where required for NMC efficiency verification, should be as a C_2H_6 and purified synthetic air mixture.

2.12.2 N_2O calibration and span gases should be as a N_2O and purified nitrogen mixture.

2.12.3 H_2O calibration and span gas should be as a H_2O and purified synthetic air or nitrogen mixture or an alternative approach as agreed to by the Administration.

2.13 Analysers should have an ongoing zero and span check capability in order to periodically verify that the zero or span drift has not exceeded 2% of full scale of the selected range. In order to avoid the zero or span drift exceeding 2% full scale of the range used, the zero and/or span values should be capable of being reset as required. Analyser span gases should be between 80% to 100% of the analyser scale being spanned.

2.14 Alternative arrangements to those required by 2.13 may be accepted, subject to the approval of the Administration, provided that the resulting zero or span drift is verified as being no more than 2% full scale of the range selected.

2.15 Extractive sampling systems

2.15.1 For each engine to be monitored the exhaust gas sample probe, of either a centreline or multi-hole – closed-end design, should extract from a zone covering 10% to 90% of the exhaust duct internal diameter.

2.15.2 The sample transfer line should be constructed of suitable material and maintained at a temperature sufficient to prevent the deposition or condensation of exhaust gas components.

2.15.3 The gas sampling system should have an ongoing procedure to periodically verify that the sampling system meets the requirements of section 4 of appendix IV of the NTC 2008 in respect of ingress leakage.

2.15.4 The exhaust gas sample as analysed may be in a wet or dry condition according to the design and operating arrangements of the analysers which are to be used. A gas-drying device, if used, should have minimal effect on the composition of the gases to be measured and should meet the requirements of 1.2.13 of appendix III of the NTC 2008. Chemical dryers should not be used.

2.15.5 Where an analyser is used to process exhaust gas samples from more than one engine's exhaust duct, a flushing arrangement should be provided of sufficient duration to ensure that the gas stream as analysed and reported to the data recording device as required by 5.5 is representative of the exhaust gas emitted from the engine to which the analyser's output signal will be assigned.

3 Determination of exhaust gas flow rate

3.1 Where required, the exhaust gas flow rate should be determined by either:

.1 carbon balance method; or

.2 direct measurement method.

3.2 Carbon balance method

3.2.1 The measured values required for the carbon balance method, as given by appendix VI of the NTC 2008, should be obtained in accordance with the requirements of this paragraph.

3.2.2 The exhaust gas CO_2 concentration should be measured in accordance with the requirements of section 2 as applicable. The background, ambient CO_2ad value should be set to 0.03%.

3.2.3 It is not required to measure the exhaust gas CO concentration and in the calculation procedure CO should be set to zero.

3.2.4 Where the engine operates on a methane based gas fuel, the CH_4 concentration should be measured and used in place of HC in the calculation procedure if HC is not separately measured in accordance with 1.2.9 and 3.3 of appendix III of the NTC 2008. Where the CEMS is to report only N_2O emissions to the atmosphere it is not required to measure HC and in the calculation procedure HC should be set to zero.

3.2.5 Liquid fuel mass basis composition, in terms of carbon, hydrogen and nitrogen, may be obtained by:

.1 analysis of a representative sample of the liquid fuel used;

.2 use of default values as given in table 5 for petroleum-derived fuel oils; or

.3 in the case of liquid fuels not covered by table 5, use of default values as agreed to by the Administration.

Table 5: Petroleum-derived fuel oils: default composition values

Sulphur content:	Carbon %	Hydrogen %	Nitrogen %
≤ 0.10 %	87.5 %	12.44 %	0.0 %
> 0.10 - ≤ 0.50 %	87.0 %	12.35 %	0.2 %
> 0.50 %	85.0 %	11.90 %	0.4 %

3.2.6 Methane based gas fuel mass basis composition, in terms of carbon, hydrogen and nitrogen, may be obtained by:

.1 analysis of a representative sample of the gas fuel used; or

.2 calculation from the cargo certificate of quality, in the case of boil-off gas, or the bunker delivery note, in the case of a supplied gas fuel on the basis of:

Carbon % $= (100 - N_2\ \%) \cdot 0.75$
Hydrogen % $= (100 - N_2\ \%) \cdot 0.25$

3.2.7 The absolute humidity value, H_a or H_{sc} as appropriate, should be determined in accordance with section 5.12.3.2.1 of the NTC 2008 for H_a or 5.12.4.6 of the NTC 2008 for H_{sc}.

3.2.8 The liquid fuel mass net flow consumption rate of the monitored engine should be determined by direct measurement on either a mass flow or volume flow – temperature compensated basis.

3.2.9 As an alternative to the requirements of paragraph 3.2.8, where for a dual-fuel engine, the liquid fuel mass flow rate does not exceed 10% of the gas fuel flow rate, the engine builder's declared liquid fuel rates as given in the CEMS file, as agreed to by the Administration, may instead be used.

3.2.10 The gas fuel mass net flow consumption rate of the monitored engine should be determined by direct measurement on either a mass flow or volume flow – temperature and pressure compensated basis.

3.2.11 The engine performance and ambient condition monitoring equipment used to provide data for the carbon balance method should be installed and maintained in accordance with the respective manufacturers' recommendations such that the requirements of section 1.3 and table 3 or table 4 of appendix IV of the NTC 2008 are met in respect of the possible deviations.

3.3 Direct measurement method

3.3.1 In order to apply the direct measurement method, the following parameters should be measured:

.1 exhaust gas mean velocity (m/s)[2];

.2 exhaust duct relative pressure (kPa) at the position where .1 is measured;

.3 exhaust gas temperature (K) at the position where .1 is measured; and

.4 barometric pressure p_b (kPa).

3.3.2 The exhaust gas and ambient condition measurement devices used to provide data for the application of the direct measurement method should be installed and maintained in accordance with the respective manufacturers' recommendations such that the requirements of section 1.3 and table 3 or table 4 of appendix IV of the NTC 2008 are met in respect of the possible deviations.

[2] Guidance on the installation requirements for devices to measure exhaust gas velocity is provided in appendix 5 of these Guidelines.

3.3.3 Where there is an arrangement by which the exhaust gas stream from a monitored engine could bypass the exhaust velocity measurement point:

.1 whenever the CEMS is in operation, there should be a continuously operating monitoring system fitted to all such bypass arrangements. The monitoring system should be capable of detecting whether the bypass is not shut or is subject to leakage. The bypass monitoring system should be approved by the Administration; and

.2 where the bypass monitoring system as required by paragraph 3.3.3.1 detects that a bypass is not shut or is subject to leakage, a signal indicating that should be transmitted to the data recording device as a fault condition to be recorded under 5.12.

3.3.4 In order to assess whether the means used to measure the exhaust gas flow are within the permitted deviation as given by table 3 of appendix IV of the NTC 2008 at the time of installation and at intervals not exceeding 12 months thereafter or whenever the data screening as required by 4.4 or 4.12 indicates an validity issue, the values determined at four equally spaced loads across the used load range of the engine should be cross-checked by comparison with the application carbon balance method, as given by 3.2, at each of those load points. The CO_2 analyser and the other measurement equipment required to perform that carbon balance method check need not be permanently installed but are required to meet the requirements of section 2 as applicable.

3.3.5 An alternative procedure to the requirements of 3.3.4 in respect of exhaust gas flow rate verification may be used, subject to approval by the Administration, provided it can be so shown by that procedure that the exhaust gas flow rates across the used load range of the monitored engine are within the permitted deviation as given by table 3 of appendix IV of the NTC 2008.

4 Calculation procedures

4.1 The end point of the calculation procedures of this Guideline is to quantify, by weight (kg), the emission to the atmosphere of CH_4 and / or N_2O over a reporting interval (RI), as given by 5.14, at the time of measurement.

4.2 The calculation steps which are to be followed, as given by the CEMS file, may be undertaken offline or, to the extent required, may be automated and undertaken in real-time. In either case the same requirements apply to the processing of the measured, input and default - fixed data through to the required end value of CH_4 and / or N_2O emitted over the particular reporting interval as applied at the time of measurement.

4.3 The calculation procedure should include the following steps:

.1 screening of all measured and input data;

.2 alignment of device output signals, as applicable;

.3 intermediate calculations, as applicable;

.4 determination of CH_4 and / or N_2O, as required, emission quantity over the reporting interval; and

.5 review of outcomes of intermediate and CH_4 and / or N_2O emission quantity calculations.

4.4 Measured or input data screening

4.4.1 All measured and input data, as recorded in accordance with section 5, should be screened for validity prior to use in the calculation procedures.

4.4.2 The screening of each data item should be against an ongoingly developed expected value range for the fuel type and mix and engine load which should also take into account such aspects as ambient conditions and other potentially influencing factors in accordance with the procedure as given in the CEMS file. Guidance as to this screening procedure is provided in appendix 6. Where a measured or input value is found to be outside the expected range, it should be evaluated as to whether it is a valid, representative, value. If it is a valid value, even if outside the expected range, then it should be used in the calculation procedure as applied and comment covering that finding entered into the CEMS record book. If it is found not to be a valid value, then that finding and the determined reasons for the error together with the resolving action taken should be recorded under section 5.12 and in the CEMS record book.

4.4.3 The screening of measured data should also be used to filter out signal spikes which do not reflect the actual parameter being measured. Where such spikes are removed from the data prior to use in the calculation procedures, a comment covering that action should be entered into the CEMS record book.

4.5 Signal alignment

4.5.1 Owing to time lags through the engine, and any emission abatement device if fitted, together with potentially differing response times between the various measurement devices used, it may be necessary to align all data to a common time reference. This need for signal alignment should also be taken into account where an analyser is to monitor the exhaust gas emissions from more than one engine.

4.5.2 Where signal alignment is required, the procedure by which that is to be undertaken should be detailed in the CEMS file.

4.6 Intermediate calculation – dry / wet correction

4.6.1 Where an emission species is not measured on a wet basis it should be converted, as required, to a wet basis using one of the following methods:

4.6.2 Calculation of dry / wet correction factor

4.6.2.1 The dry / wet correction factor should be calculated in accordance with section 5.12.3 of the NTC 2008.

4.6.2.2 Measurement of CO_2 should be in accordance with the relevant requirements as given by section 2. CO is not required to be measured and should be taken as zero.

4.6.2.3 The carbon and hydrogen content values of the fuel or fuels as used should be obtained in accordance with paragraph 3.2.5 or 3.2.6, as appropriate.

4.6.2.4 Where $H_a \geq H_{sc}$, with H_{sc} as calculated in accordance with paragraph 5.12.4.6 of the NTC 2008, then H_{sc} should be used instead of H_a in the calculation.

4.6.2.5 If water or steam is added or injected into the fuel oil as is to be used, charge air, engine combustion chamber or exhaust gas stream prior to the measurement or sampling position, then the metered quantity so added or injected should also be taken into account when determining the applicable dry / wet correction factor using a procedure approved by the Administration. That procedure should be detailed in the CEMS file.

4.6.2.6 If the water content of the exhaust gas stream, as a product of the inlet air humidity and water formed by combustion, is reduced by exhaust gas duct arrangements or devices prior to the measurement or sampling position, then either sections 4.6.3 or 4.6.4 should instead be used.

4.6.3 Direct measurement of water content

4.6.3.1 Where the water vapour content of the exhaust gas stream is directly measured the analyser used should meet the relevant requirements of section 2.

4.6.3.2 The dry / wet correction factor from direct measurement:

$$k_{wr3} = (1 - c_{H2Ow}/100) \cdot 1.008$$

where:

c_{H2Ow} = measured water vapour concentration (%)

4.6.4 Indirect measurement of water content

4.6.4.1 Where the water vapour content of the exhaust gas stream is to be determined by the measurement of both the wet and dry concentrations of oxygen before and after the dryer unit that should be undertaken using a zirconium dioxide sensor meeting the requirements of section 2.

4.6.4.2 The dry / wet correction factor from indirect measurement:

$$k_{wr4} = O_2w/O_2d$$

where

O_2w = Measured O_2 concentration – wet basis (%)

O_2d = Measured O_2 concentration – dry basis (%)

4.7 Intermediate calculation – NMC CH_4 correction

4.7.1 Where the NMC methane efficiency is not 0 % and/or the NMC ethane efficiency is not 100 %, the corrected CH_4 concentration to be used in paragraphs 4.10.1 and 4.11.1 should be calculated as follows:

$$c_{CH4corr} = \frac{c_{HC}(wCutter) \cdot (1 - E_m) - c_{HC}(w/oCutter) \cdot (1 - E_e)}{E_e - E_m}$$

where:

c_{HC} (wCutter) = HC concentration with sample gas through NMC (ppmC1)

c_{HC} (w/oCutter) = HC concentration with NMC bypassed – i.e. usual HC reading (c_{HC}) (ppmC1)

E_m = NMC methane efficiency (see appendix 4)

E_e = NMC ethane efficiency (see appendix 4)

4.8 Intermediate calculation – exhaust gas mass flow rate by carbon balance

4.8.1 The calculation of the exhaust gas mass flow rate by the carbon balance method should be undertaken in accordance with the procedures as given by appendix VI of the NTC 2008.

4.9 Intermediate calculation – exhaust gas volume flow rate by direct measurement

4.9.1 The exhaust gas volume flow rate under reference conditions (101.3 kPa, 273 K) should be calculated as follows:

$$q_{vew} = \frac{v_n \cdot D^2 \cdot \pi \cdot 3600 \cdot P_{da} \cdot T_{ref}}{4 \cdot T_d \cdot P_{ref}}$$

where:

q_{vew} = exhaust gas volume flow rate at reference conditions (Nm^3/h)

v_n = mean velocity of exhaust gas (m/s)

D = internal diameter of exhaust duct at point of velocity measurement (m)

P_{da} = absolute pressure of exhaust gas in the duct = P_{dr} + P_b

P_{dr} = relative pressure of exhaust gas in duct (kPa)

P_b = barometric pressure (kPa)

T_{ref} = reference temperature: 273 (K)

T_d = temperature of exhaust gas at point of velocity measurement (K)

P_{ref} = reference pressure: 101.3 (kPa)

4.10 Intermediate calculation (CH_4 only) - direct calculation of the methane slip method

4.10.1 For the application of this method, methane slip % should be calculated as follows:

$$c_{slip\text{-}CH4} = \frac{CH_4\mathrm{m}}{\frac{CO_2\mathrm{m}}{GF\text{-}C_f + LF_{mf} \cdot LF\text{-}C_f} + CH_4\mathrm{m}} \cdot 100$$

where:

$C_{slip\text{-}CH4}$ = methane slip (%)

CH_4m = CH_4 (mg/m^3)

= CH_4 (ppm) · 0.716

CO_2m = CO_2 (mg/m^3)

= CO_2 (%) · 10,000 · 1.964

Note: CH_4 (ppm) and CO_2 (%), as used above, are to be either both dry basis readings or both to the same wetness fraction. Where it is necessary to convert a dry basis reading to a wet basis then one of the Dry / Wet Correction options as given by section 4.6 should be used.

$GF\text{-}C_f$ = gas fuel carbon factor

= carbon % (from 3.2.6) · 0.03664

$LF\text{-}C_f$ = liquid fuel carbon factor

= carbon % (from 3.2.5) · 0.03664

LF_{mf} = liquid fuel mass fraction (to a precision of not less than three decimal places)

$$= \frac{\text{liquid fuel mass flow rate (kg/h)}}{\text{gas fuel mass flow rate (kg/h)}}$$

Note: For the purposes of these Guidelines a fuel which is not a methane based gas fuel should be regarded as a liquid fuel

4.10.2 The exhaust gas CH_4 and CO_2 concentrations should be measured in accordance with the requirements of section 2 as applicable.

4.10.3 The liquid fuel mass net flow consumption rate of the monitored engine should be determined by direct measurement on either a mass flow or volume flow – temperature compensated basis.

4.10.4 As an alternative to the requirements of paragraph 4.10.3, where, for a dual-fuel engine, the liquid fuel mass flow rate does not exceed 10% of the gas fuel flow rate, the engine builder's declared liquid fuel rates as given in the CEMS file, as agreed to by the Administration, may instead be used.

4.10.5 The gas fuel mass net flow consumption rate of the monitored engine should be determined by direct measurement on either a mass flow or volume flow – temperature and pressure compensated basis.

4.10.6 The fuel flow meters and other measurement devices to be used in the application of the direct calculation of methane slip method should be installed and maintained in accordance with the respective manufacturers' recommendations such that the requirements of section 1.3 and table 3 or table 4 of appendix IV of the NTC 2008 are met in respect of the possible deviations.

4.11 Determination of CH_4 and / or N_2O emission quantity over the reporting interval

4.11.1 The CH_4 and / or N_2O emission quantity (kg), to a precision of at least one decimal place, over a reporting interval, as given by 5.14, should be calculated, as applicable, from the data as recorded in accordance with section 5, as follows:

$$q_{mgas} = u_{gas} \cdot c_{gas} \cdot q_{mew} \cdot RI / 1000$$

$$= w_{gas} \cdot c_{gas} \cdot q_{vew} \cdot RI / 1000$$

$$= C_{slip\text{-}CH4} \cdot m_{fg} \cdot RI / 100$$

where:

q_{mgas} = mass of CH_4 or N_2O emitted to atmosphere over the reporting interval (kg)

u_{gas} = as given by appendix 2 of these guidelines

w_{gas} = as given by appendix 2 of these guidelines

c_{gas} = wet basis concentration of CH_4 corrected or N_2O (ppm)

Note: where a NMC is used the c_{gas} CH_4 value is the value as corrected by 4.7.1.

q_{mew} = exhaust gas mass flow rate (g/h) – 4.8.1

q_{vew} = exhaust gas volume flow rate at reference conditions (Nm^3/h) – 4.9.1

RI = reporting interval used at time of measurement (h) – 5.14

$C_{slip\text{-}CH4}$ = % CH_4 Slip – 4.10.1

m_{fg} = gas fuel mass flow rate (kg/h) – 4.10.5

4.11.2 In the case of CH_4 reporting, where the crankcase emissions from trunk piston engines are not led to the exhaust duct upstream of the CH_4 measurement or sampling point, the outcome of the quantification under 6.1.2.1.7.2 should be added to the outcome of paragraph 4.11.1.

4.12 Review of outcomes of intermediate and CH_4 or N_2O emitted quantity calculations

4.12.1 The outcomes of the intermediate and CH_4 or N_2O emitted quantity calculations should be screened for possible calculation errors.

4.12.2 The review of each calculated value should be against an ongoingly developed expected value range for the fuel type and mix and engine load which should also take into account such aspects as ambient conditions and other potentially influencing factors in accordance with the procedure as given in the CEMS file. Guidance as to this screening procedure is provided in appendix 6 of these guidelines. Where a calculated value is found to be outside the expected range it should be evaluated as to whether it is a valid calculated value. If it is a valid calculated value, then it should be retained. If it is found not to be a valid calculated value, then that finding and the determined reasons for that error, together with the resolving action taken, should be recorded under paragraph 5.13 and in the CEMS record book.

5 Data recording device

5.1 The data recording device should be of a robust, tamper-proof design meeting the requirements of section 4 of the *Guidelines for the use of Electronic Record Books under MARPOL Annex VI*[3].

[3] Resolution MEPC.312(74) on *Guidelines for the use of electronic record books under MARPOL.*

5.2 Where the calculations in accordance with section 4 are to be undertaken on board in an automated manner as part of the CEMS, those processing functions should be considered to be an inherent part of the data recording device and all requirements related to that device should be considered to be equally applicable, as appropriate, to its data processing functions.

5.3 Where a CEMS covers more than one engine, appropriate arrangements, as agreed to by the Administration, should be in place to ensure that the data recorded for each engine is clearly distinguished so that the data in respect of each engine can be readily identified, duly recorded and reported as required.

5.4 The data recording device should record whenever an engine, identified under paragraph 6.1.1.2, is in operation and whether or not the engine operating conditions identified under paragraph 6.1.1.3 apply.

5.5 Whenever the CEMS is in operation the data recording device should, as a minimum, record the following:

.1 the averaged output, over the reporting interval applied, of each of the exhaust gas analysers as listed in the CEMS file. The output from analysers for CO_2, H_2O and O_2 should be recorded in terms of % to a precision of not less than two decimal places. The output from analysers for CH_4 and /or N_2O should be recorded in terms of ppm to at least the nearest whole number;

.2 the outcomes of the zero and span checks of the exhaust gas analysers as listed in CEMS file including the evaluation and acceptability of any zero or span drift together with subsequent resets of the respective zero / span values;

.3 where an Administration has, under paragraph 2.14, approved an alternative approach to the zero / span check procedure, data showing the functionality of that approach so that drift does not exceed 2% of the full scale of the range used;

.4 where exhaust gas analysers are used in an extractive sampling arrangement, the measured values of the sample transfer line leak test procedure used and the evaluation together with the pass / fail assessment of that finding;

.5 where the carbon balance method is used to calculate exhaust gas mass flow rate, the averaged measured values, over the reporting interval applied, are used in that calculation;

.6 where the direct measurement method is used to calculate exhaust gas volume flow rate at reference conditions, the averaged measured values, over the reporting interval applied, are used in that calculation;

.7 where the direct calculation of the methane slip method is used, the averaged measured net fuel flow rates and other measured values, over the reporting interval applied, are used in that calculation;

.8 where the dry/wet correction factor is to be calculated or determined, the measured values, averaged over the reporting interval applied, are used in that calculation or determination;

.9 for extractive sampling systems incorporating a sample gas dryer, the sample gas outlet temperature from the dryer, averaged over the reporting interval applied;

.10 other measured data as used in the calculation processes or which are used indicate the operating condition of the CEMS or component parts thereof;

.11 other measured data used in the application of alternative or additional procedures, as agreed to or approved by the Administration, to those given by these Guidelines; and

.12 periods when the required data is not being transmitted to the data recorder owing to the agreed maintenance periods as given by paragraph 6.1.8.2.

5.6 The data recording device should record the following input data together with the time-date range over which they apply:

.1 zero and span gas composition data together with respective validity dates of those zero or span gases;

.2 if applicable, determined liquid fuel composition data;

.3 if applicable, determined gas fuel composition data;

.4 where an NMC is used, E_m and E_e;

.5 where the provisions of either paragraph 3.2.9 or 4.10.4 are followed, the derived liquid fuel mass flow rates are used;

.6 other input data as used in the calculation procedures applied; and

.7 other input data used in the application of alternative or additional procedures, as agreed to or approved by the Administration, to those given by these Guidelines.

5.7 The data recording device should have the capability to upload and store copies of the test certificates or other documentation from which the input data under paragraph 5.6 was obtained.

5.8 The data recording device should record the default values used and, if applicable, the time-date range, or other criteria, over which they apply together with any fixed values used in the calculation procedures:

.1 if applicable, default liquid fuel composition data;

.2 if applicable, exhaust duct internal diameter at the point of velocity measurement;

.3 other default or fixed values used in the calculation procedures applied; and

.4 other default or fixed values used in the application of alternative or additional procedures, as agreed to by the Administration, to those given by these Guidelines.

5.9 The data recording device should record the following intermediate calculation values determined for each reporting interval:

.1 if NMC is used, the E_m and E_e corrected CH_4 concentration;

.2 if used, absolute humidity values and whether that is as H_a or H_{sc};

.3 if used, dry / wet correction factor;

.4 if the carbon balance method is used, the exhaust gas mass flow rate (kg/h);

.5 if the direct measurement method is used, the exhaust gas volume flow rate at reference conditions (Nm^3/h);

.6 if the direct calculation of the methane slip method is used, the $C_{slip\text{-}CH4}$ value; and

.7 calculated values related to the application of alternative or additional procedures, as agreed to or approved by the Administration, to those given by these Guidelines.

5.10 The data recording device should record:

.1 the determined weight, expressed in kg, of CH_4 and / or N_2O emission to the atmosphere, as determined under section 4.11 and screened by section 4.12 as valid, for each reporting interval; or

.2 for each reporting interval during a zero/span check procedure as recorded under paragraph 5.5.2 or 5.5.3, a leak check procedure as recorded under paragraph 5.5.4 or an agreed CEMS maintenance period as recorded under paragraph 5.5.12, the CH_4 and / or N_2O emission (kg) to atmosphere as the average of that of the last reporting interval before reporting ceased and that of the first reporting interval following stabilization on restart.

5.11 Where the calculations in accordance section 4 of these Guidelines are undertaken remotely from the CEMS, the data recording device should be capable of being uploaded with the data required by paragraphs 5.6, 5.7, 5.8, 5.9 and 5.10.

5.12 The data recording device should record those periods when the CEMS was not able to generate the CH_4 and / or N_2O emission value required by paragraph 5.10.1 owing to:

.1 non-availability of data due to malfunction or failure of an identified exhaust gas analyser, other measurement device or necessary item of support equipment which forms part of the CEMS. Such periods are outside those provided for by paragraph 5.10.2;

.2 a measurement or input data fault condition, as identified by the screening required by section 4.4, and should additionally record details of the fault which resulted in that inability to provide valid data. The related inputs for this function may be manual, automated or a mix of both;

.3 a fault detected by the zero or span check facility required by paragraph 2.13 or 2.14 by which the zero or span drift exceeded 2% of the full scale of the range used. That fault condition should be applied to all data recorded since the last data point where the zero or span drift was within the required range. This function should be automated;

.4 in the case of an extractive sampling system, where the sample line leak detection procedure, required by paragraph 2.15.3, detects that there is an ingress leakage. That fault condition should be applied to all data recorded since the last data point where the sampling system was verified as free of ingress leakage. This function should be automated; and

.5 the monitoring system required by paragraph 3.3.3 detecting that a bypass arrangement was either not shut or subject to leakage. This function should be automated.

5.13 The data recording device should also record periods when the CEMS was not able to generate the CH_4 and / or N_2O emission value required by paragraph 5.10.1 owing to calculation fault conditions, as identified by the review required by section 4.12, and should additionally record details of the fault which resulted in that error. The related inputs for this function may be manual, automated or a mix of both.

5.14 The recording undertaken in accordance with paragraphs 5.4, 5.5, 5.9, 5.10, 5.12 and 5.13 should be against UTC with a reporting interval (RI) not greater than 0.20 hours. Where required, shorter reporting intervals may be used in order to cover periods of different engine operating conditions.

5.15 The data recording device should be capable of preparing and downloading reports in a readily usable format over user selected time-date ranges covering, but not limited to, the following either individually or as a user selected combined report:

.1 periods of engine operation and engine operating condition under section 5.4;

.2 measured data values under paragraph 5.5;

.3 input values under paragraph 5.6 and the associated supporting data under paragraph 5.7;

.4 default or fixed values under paragraph 5.8;

.5 intermediate calculated values under paragraph 5.9;

.6 CH_4 and / or N_2O emitted to the atmosphere for each reporting interval under paragraph 5.10;

.7 CH_4 and / or N_2O emitted to atmosphere;

.8 occurrence and duration of zero/span check periods, leak check periods and maintenance periods, as allowed by paragraph 6.1.8.2, which interrupted the CEMS from generating the required output under paragraph 5.10.1; and

.9 occurrence, duration and summary details of fault conditions which prevented the CEMS from operating as required as recorded under paragraphs 5.12 or 5.13.

5.16 The data recorded should be retained on board for a period of not less than 18 months from the date of recording. If the data recording device is changed over that period, it should be ensured that the required data is retained on board and available as required for surveys or inspections.

6 CEMS documentation

6.1 CEMS file

6.1.1 For each CEMS there should be a CEMS file, prepared by the applicant and approved by the Administration. The CEMS file should be retained on board the ship on which the CEMS is installed and be available for surveys and inspections as required. The CEMS file should, as a minimum, contain:

.1 whether CH_4, N_2O or both are to be monitored and reported;

.2 identify the engine, or engines, whose exhaust gas streams the CEMS is to monitor;

.3 under what engine operating conditions the CEMS is intended to operate[4]; and

.4 the information required by paragraphs 6.1.2 to 6.1.10.

6.1.2 Marine diesel engine

6.1.2.1 Details of the marine diesel engine, or engines, the exhaust emissions of which the CEMS is to monitor. Those details should include, but are not limited to:

.1 engine onboard reference and duty;

.2 manufacturer, model number and serial number;

.3 rated power and rated speed;

.4 NO_x certification 'engine approval number';

.5 where fuel oil consumption is to be measured as part of these procedures, details should be given of the fuel flow meters to be used and other associated measurement devices together with the calculation procedures, if required, to present the data on a net mass flow basis. The relevant fuel oil service system piping diagrams should be included showing the location of the fuel flow measurement devices;

.6 diagram giving the layout of the engine's exhaust gas system including all incorporated devices and any bypass arrangements; and

.7 where CH_4 is to be monitored and reported, in the case of trunk piston engines using a methane based gas fuel, the means by which the crankcase emissions of CH_4, in terms of kg of CH_4 over each reporting interval, are to be determined:

.1 where the crankcase vent, or vents, discharge only into either the engine's intake air or the exhaust duct at a position upstream of the exhaust gas sampling position, that arrangement should be detailed on the exhaust gas piping diagram as required by paragraph 6.1.2.1.6; or

[4] It may, for example, be given that the CEMS is only intended to operate when the engine is in a dual fuel mode, or not under 'standby' conditions, or not under a certain minimum % of rated power or speed.

.2 where the crankcase vent does not discharge into the engine's inlet air or exhaust duct at a position upstream of the measurement or sampling position:

.1 The procedures by which the total CH_4 crankcase emissions are to be quantified in terms of kg CH_4 over each reporting interval, as agreed to by the Administration. In the case where the crankcase has more than one outlet, the means by which the CH_4 emissions from each outlet are to be determined, in terms of kg CH_4 over each reporting interval, should be given. The influence of crankcase ventilation systems on that quantification should also be described, including any mitigation or correction procedures applied so that the reported CEMS data accurately reflects the total crankcase CH_4 emissions for each reporting interval; or

.2 The crankcase emissions of CH_4, in terms of kg of CH_4 over each reporting interval, should be derived from the engine builder's advised values, taking into account relevant influencing factors including, but not limited to, design specifics, torque, speed and time between top-end overhauls.

6.1.3 CH_4 and / or N_2O emission reduction device

6.1.3.1 Where a CH_4 and / or N_2O emission reduction device is fitted, details of the device should be given. Those details should include, but are not limited to:

.1 the exhaust emission component(s) intended to be reduced;

.2 the manner of operation of the reduction device, including details and criteria governing usage of any required energy inputs and/or consumables;

.3 the engine operating conditions under which the reduction device is intended to function; and

.4 the arrangement of the reduction device relative to the layout of the exhaust system as required by paragraph 6.1.2.1.6.

6.1.4 Exhaust gas analysers

6.1.4.1 Details of each exhaust gas analyser device which are to form part of the CEMS should be given. Those details for each such device should include, but are not limited to:

.1 measured exhaust emission component;

.2 analyser manufacturer and model;

.3 measurement principle. Where that measurement principle differs from that given by paragraph 2.3 the approval certification of that equivalent means as issued by the Administration;

.4 details of any necessary ancillary components or system requirements necessary for the analyser to function;

.5 whether that analyser measures on a wet or dry basis;

.6 if required, the means by which a dry basis reading will be corrected to wet basis, or wet to dry, together with:

.1 details of the measurement equipment necessary to apply that dry/wet correction; and

.2 the means by which other required data to perform that dry / wet correction will be obtained;

.7 analyser ranges to be used and the criteria for any range change;

.8 zero and span gas compositions, as applicable;

.9 if applicable, details of the zero and span check procedures, the frequency of that operation and the means by which the analyser would be reset such that the drift, in either case, does not exceed 2% full scale of the range used. Additionally, it should be given that such zero and span checks should only be undertaken under steady CH_4 and / or N_2O emission rate conditions, as indicated by paragraph 5.5 or as recorded by paragraph 5.10.1 prior to undertaking that check;

.10 the minimum reporting interval required in order to obtain a stable reading from the analyser;

.11 where a NMC is used, details of that device including CH_4 / NMHC ranges and design E_m and E_e efficiencies; and

.12 where an analyser is to be used to monitor the exhaust gas emissions from more than one exhaust duct, the means by which it will be ensured that the analysed gas sample will be representative of the engine to which the findings will be assigned. This is to also cover sample switching, flushing, how the gas sample in the disengaged sample feed lines will remain updated, the T_{90} response factors (that is the time required for the analyser's output signal to register 90% of the input change) of the analysers involved and other relevant factors particular to the proposed system. This arrangement is to be agreed to by the Administration.

6.1.4.2 In the case of extractive sampling systems, details of the individual components of that system should be given which should include, but are not limited to:

.1 sample probe - design, fittings, and materials;

.2 sample transfer lines - operating temperatures and materials;

.3 if fitted, sample filter arrangements;

.4 if fitted, sample dryer - operating principle and exhaust gas sample outlet temperature range; and

.5 details of the leak check procedure to be applied and the frequency of that operation. Additionally, it should be given that such leak checks should only be undertaken under steady CH_4 and / or N_2O emission rate conditions, as indicated by paragraph 5.5 or as recorded by paragraph 5.10.1 prior to undertaking that check.

6.1.4.3 A diagram should be included showing the arrangement of the exhaust gas analysers and any associated devices or systems relative to the layout of the exhaust system as required by paragraph 6.1.2.1.6.

6.1.5 Exhaust gas flow

6.1.5.1 Where the exhaust gas flow rate is to be determined, it should be given whether that is to be by means of the carbon balance method or the direct measurement method:

6.1.5.2 Where the carbon balance method is to be used:

.1 details of the measurement devices necessary to apply the carbon balance method;

.2 a diagram showing the arrangement of those measurement devices relative to the layout of the exhaust system as required by paragraph 6.1.2.1.6;

.3 the means by which fuel composition data required for the carbon balance method will be obtained;

.4 where the provisions of paragraph 3.2.9 are to be followed, the derived liquid fuel mass flow rate to be used across the load engine range. If there is more than one such rate, the basis by which the particular liquid fuel rate would be selected should be given; and

.5 the means by which the exhaust gas water vapour content is to be determined.

6.1.5.3 Where the direct measurement method is to be used:

.1 details of the exhaust gas velocity measurement device to be used including its declared maximum deviation across the required operating range when used with exhaust gas;

.2 details of the installation requirements of the velocity measurement device;

.3 exhaust duct internal diameter at the point of velocity measurement;

.4 details of the other measurement equipment necessary to apply the direct measurement method;

.5 the means by which the exhaust gas water vapour content, if required, is to be determined;

.6 a diagram should be included showing the arrangement of the required measurement devices relative to the layout of the exhaust system as required by paragraph 6.1.2.1.6;

.7 where there is an arrangement by which the exhaust gas stream from a monitored engine could bypass the exhaust gas velocity measurement point, details should be provided of the Administration agreed monitoring system as required by paragraph 3.3.3; and

.8 details of the procedures to be applied to verify that the exhaust gas flow rates across the used load range of the monitored engine are within the permitted deviation limit as given by table 3 of appendix IV of the NTC 2008.

6.1.6 Calculation procedures

6.1.6.1 It should be given as to whether the required calculations, are to be undertaken offline or, to the extent required, automated and undertaken in real-time.

6.1.6.2 Details of the measured and input data screening procedure as required by paragraph 4.4 should be given. For each measured or input parameter to be used in the calculation procedures to be applied, the initially expected value range should be given for the engine loads and fuel types and mixes to be covered. These procedures should also cover how this aspect of the data screening procedure is to be informed from subsequent in service measured or input data and how it may be affected by such as ambient conditions and other relevant potentially influencing factors. The procedure should also cover the evaluation of measured or input values falling outside the expected range as to whether or not they represent valid values together with, where they are not valid, the resolving action to be taken. Guidance on the development of this screening procedure is provided in appendix 6.

6.1.6.3 Details should be given of the signal alignment procedure, if required, in accordance with 4.5. That procedure should give which baseline parameter the other signals are to be aligned to together with the rationale of that selection.

6.1.6.4 Where the provisions of paragraph 4.10.4 are to be followed, the derived liquid fuel mass flow rate to be used across the load engine range. If there is more than one such rate, the basis by which the particular liquid fuel rate would be selected should be given.

6.1.6.5 All intermediate calculations which are to be undertaken should be given. Where default values are to be used those should be given relative to the criteria for their application.

6.1.6.6 The means by which the CH_4 and / or N_2O emission quantity is to be calculated over each reporting interval in accordance with section 4.11 should be given.

6.1.6.7 Details of the procedures for the review of the outcomes of the intermediate and CH_4 and / or N_2O emitted quantity calculations as required by section 4.12 should be given. For each calculated item, the initially expected value range should be given for the engine loads and fuel types and mixes to be covered. These procedures should include how this aspect of the data screening procedure is to be informed from subsequent in service calculated data. The procedure should also cover the evaluation of calculated values falling outside the expected range as to whether or not they represent valid values together with, where they are not valid, the resolving action to be taken. Guidance as to the development of this review procedure is provided in appendix 6 of these guidelines.

6.1.7 Data recording device

6.1.7.1 Details should be given of the data recording device. Those details should include information showing that the design of that device meets the requirements of section 4 of the *Guidelines for the use of Electronic Record Books under MARPOL*[5].

6.1.7.2 The reporting interval to be used should be given. Where the reporting interval may be altered, the criteria for the selection of the particular reporting interval, together with the range of reporting intervals to be used, should be given.

6.1.7.3 The real-time measurement, input and calculated value data streams to the data recording device as required by paragraphs 5.5, 5.6 and 5.9, respectively should be given.

6.1.7.4 The means by which the uploading of data as required by paragraph 5.7 is to be undertaken should be given.

6.1.7.5 The default values to be used under 5.8 and, if applicable, whether there would be a time-date range, or other criteria, over which they would apply together with any fixed values used in the calculation procedures, should be given.

6.1.7.6 Where calculation procedures are to be undertaken offline, details of the procedure and frequency for uploading the processed data into the data recording device, as required by paragraph 5.11, should be given. That frequency should not be more than 30 days from the date on which the measurements were undertaken.

6.1.7.7 Details should be given of the means by which reports, as required, may be obtained in accordance with paragraph 5.15.

6.1.7.8 The period over which, in accordance with paragraph 5.16, data will be retained on board should be given. Procedures covering the possible change of the data recording device should also be given.

6.1.8 CEMS maintenance

6.1.8.1 Details should be given of the routine maintenance requirements of the CEMS and its component parts so that it continues to function as intended and to meet the requirements of these Guidelines. In this reference may be made to the respective manufacturer's specified documentation, which would not be required to be reproduced in the CEMS file itself. However, any such documentation should be retained on board and be available as required.

6.1.8.2 It should be given that maintenance of exhaust gas analysers, other measurement devices or necessary support equipment which form part of the CEMS should, whenever possible, be undertaken when the CEMS itself is not required to be in operation. Where that is not possible, the frequency and duration of the respective required maintenance periods should be given, as agreed to by the Administration.

6.1.8.3 It should be given that maintenance of CEMS components which interrupts the determination of the CH_4 and / or N_2O emission value under section 4.11 should be coordinated so as to minimize the overall duration when paragraph 5.10.2 applies. Additionally, it should also be given that such maintenance should only be undertaken under steady CH_4 and / or N_2O emission rate conditions, as indicated by paragraph 5.5 or recorded by paragraph 5.10.1 prior to undertaking that maintenance.

5 Resolution MEPC.312(74) as may be amended.

6.1.9 CEMS servicing

6.1.9.1 Details should be given of the servicing requirements of the CEMS and its component parts so that it continues to function as intended and to meet the requirements of these Guidelines. This should include the exhaust gas analyser calibration and interference checks as required by these Guidelines, together with the calibration checks on other measurement devices.

6.1.9.2 It should be given that servicing of exhaust gas analysers, other measurement devices or necessary support equipment which form part of the CEMS should not be undertaken when the CEMS itself is intended, by paragraph 6.1.1.3, to be in operation.

6.1.10 Additional information

6.1.10.1 The CEMS file may include any additional information the applicant considers necessary to describe the CEMS and/or its manner of operation.

6.1.10.2 The CEMS file should include any additional information the Administration considers to be necessary to describe the CEMS and/or its manner of operation.

6.1.11 Amendments to CEMS file

6.1.11.1 Any amendment to the CEMS file should be approved by the Administration, taking into account the effect of the proposed change on the performance of the CEMS, prior to the implementation of the change requiring that amendment. Where an addition, deletion or amendment to the CEMS file is separate from the CEMS file as initially approved, it should be retained with the CEMS file and should be considered as part of it.

6.2 CEMS record book

6.2.1 A CEMS record book should be maintained up to date on board and should be available for surveys and inspections as required. The format and extent of the CEMS record book should be approved by the Administration. Where the CEMS record book is to be maintained in an electronic form it should meet the relevant requirements of section 4 of the *Guidelines for the use of Electronic Record Books under MARPOL* (resolution MEPC.312(74)), as may be amended. Where the CEMS record book is to be maintained in a written form, it should cover the points as given by section 4 of the *Guidelines for the use of Electronic Record Books under MARPOL*.

6.2.2 The CEMS record book should be used to record:

.1 all maintenance actions, both as provided for under paragraph 6.1.8.1 and otherwise, undertaken on the CEMS, including like-for-like replacements;

.2 servicing actions undertaken on the CEMS including all servicing reports covering calibration, interference checks and other repair / replacement activities;

.3 open / shut status of a bypass connection as covered by paragraph 3.3.3.

.4 the corrective actions taken to resolve any fault conditions as recorded by paragraphs 5.12 or 5.13; and

.5 actions undertaken under paragraph 4.4.3 to remove signal spikes from the recorded data prior to use in the calculation procedures.

6.2.3 The CEMS record book should be retained onboard for a period of not less than two years from the date of last entry or for longer as required by the Administration.

7 CEMS certification

7.1 Prior to the use of a CEMS for the purpose of providing CH_4 and / or N_2O emission data in accordance with relevant requirements, that CEMS should be subject to an initial survey. On satisfactory completion of that survey, a CEMS Certificate, the form of which is given in appendix 1 of these guidelines, should be issued by the Administration.

7.2 Thereafter, and for as long as that CEMS continues to be used in relation to the provision of CH_4 and / or N_2O data, it should remain subject to annual surveys which should be undertaken not less than 12 months following the date of the previous survey.

7.3 The initial and annual surveys of the CEMS should confirm that the CEMS is as detailed in the CEMS file, that the CEMS functions in accordance with the relevant requirements of these Guidelines and that the procedures as given in the CEMS file are being duly applied.

7.4 Where a CEMS covers more than one engine, the initial and annual survey should verify that the arrangements to separately measure, calculate and report the emissions from each engine are operating as required.

7.5 Initial and annual surveys should include a period when the CEMS is in operation in accordance with paragraph 6.1.1.3.

7.6 At the initial survey, the screening of the CEMS measured, input and output data in accordance with the procedures detailed in the CEMS file should be demonstrated.

7.7 At annual surveys, it should be verified that the CEMS measured, input and reported data streams have been subject to the review procedures as detailed in the CEMS file.

7.8 If the CEMS is not in service at the time that an annual survey is due, an initial survey should be undertaken and, at that time a new CEMS Certificate duly issued before further CH_4 and / or N_2O emission data is provided.

7.9 At annual surveys, it should be confirmed that the CEMS record book has been maintained as required.

APPENDIX 1

FORM OF CEMS CERTIFICATE

Issued in accordance with the *Guidelines for continuous emission monitoring systems (CEMS) used to quantify methane (CH_4) and/or nitrous oxide (N_2O) emissions from marine diesel engines* (resolution MEPC.416(84)) under the authority of the Government of:

…………………………………………………………………………………………………
(full designation of the country)

by..
(full designation of the competent person or organization authorized)

Particulars of ship

Name of ship ....
IMO Number...

CEMS

CEMS file approval reference..
Engines covered by CEMS

Engine	1	2	3	4
Manufacturer:				
Model:				
Serial number:				
NO_x approval number:				

CH_4 reported – yes / no*
N_2O reported – yes / no*

THIS IS TO CERTIFY that the CEMS as installed is as detailed in the CEMS file, that the CEMS functions in accordance with the relevant provisions of the CEMS Guidelines and that the screening of the CEMS output data in accordance with the procedures detailed in the CEMS file has been satisfactorily demonstrated.

Issued at……………………………………………………………………………...
(place of issue of the Statement)

(dd/mm/yyyy): ....
(date of issue) *(signature of duly authorized official issuing the Statement)*

(seal or stamp of the authority, as appropriate)

* Delete as appropriate

ENDORSEMENT FOR ANNUAL SURVEYS

THIS IS TO CERTIFY that the CEMS as installed remains as detailed in the CEMS file, that the CEMS functions and is operated in accordance with the CEMS file and that the CEMS reported data streams have been subject to the screening procedures as detailed in the CEMS file:

Annual Survey 1

Signed …………………………………………………..
(signature of duly authorized official)

Place ....

Date (dd/mm/yyyy) ....

(seal or stamp of the authority, as appropriate)

Annual Survey 2

Signed …………………………………………………..
(signature of duly authorized official)

Place ....

Date (dd/mm/yyyy) ....

(seal or stamp of the authority, as appropriate)

Annual Survey 3

Signed …………………………………………………..
(signature of duly authorized official)

Place ....

Date (dd/mm/yyyy) ....

(seal or stamp of the authority, as appropriate)

Annual Survey 4

Signed …………………………………………………..
(signature of duly authorized official)

Place ....

Date (dd/mm/yyyy) ....

(seal or stamp of the authority, as appropriate)

Annual Survey n*

* Add as appropriate

APPENDIX 2

CH_4 AND N_2O *U*GAS AND *W*GAS VALUES

1 For the calculation of the exhaust gas mass flow rates in paragraph 4.11.1, u_{gas} values for CH_4 and / or N_2O, as required, should be calculated using table 5 of the NTC 2008 as extended by the following:

Gas		HC	CH_4	N_2O
ρ_{gas} kg/m^3		*	0.716	1.9631
	ρ_e†	Coefficient u_{gas}‡		
Liquid fuel**	1.2943	0.000479	0.000553	0.001517
Rapeseed Methyl Ester	1.2950	0.000536	0.000553	0.001516
Methanol	1.2610	0.001133	0.000568	0.001557
Ethanol	1.2757	0.000805	0.000561	0.001539
Natural gas	1.2661	0.000558*	0.000565	0.001551
Propane	1.2805	0.000512	0.000559	0.001533
Butane	1.2832	0.000505	0.000558	0.001530

In the case of dual-fuel operation, the u_{gas} value to be used should be determined from the values given above proportioned according to the respective fuel mass ratio.

* in the case of HC emissions when using natural gas as the fuel, the given u_{gas} value of 0.000558 should be used for NMHC on the basis of CH2.93. For total HC, the u_{gas} of CH_4 should be used.

2 For the calculation of the exhaust gas volume flow rate at reference conditions (Nm^3/h) in 4.11.1, w_{gas} values for CH_4 and / or N_2O, as required, should be calculated using table 5 of the NTC 2008 as extended by the following:

Gas		**HC**	**CH_4**	**N_2O**
ρ_{gas} kg/m^3		*	0.716	1.9631
	ρ_e†	Coefficient w_{gas}‡		
Liquid fuel**	1.2943	0.000620	0.000716	0.001964
Rapeseed Methyl Ester	1.2950	0.000694	0.000716	0.001964
Methanol	1.2610	0.001429	0.000716	0.001964
Ethanol	1.2757	0.001027	0.000716	0.001964

Gas		HC	CH_4	N_2O
ρ_{gas} kg/m^3		*	0.716	1.9631
Natural gas	1.2661	0.000706*	0.000716	0.001964
Propane	1.2805	0.000656	0.000716	0.001964
Butane	1.2832	0.000648	0.000716	0.001964

In the case of dual-fuel operation, the w_{gas} value to be used should be determined from the values given above proportioned according to the respective fuel mass ratio.

* in the case of HC emissions when using natural gas as the fuel, the given w_{gas} value of 0.000706 should be used for NMHC on the basis of CH2.93. For total HC, the w_{gas} of CH_4 should be used.

APPENDIX 3

CH_4 ANALYSER AND N_2O ANALYSER INTERFERENCE CHECKS

1 The interference should be checked prior to the first use of an analyser and after major servicing or updating of software.

2 In those cases where the analyser applies compensation algorithms which use as inputs the concentrations of other measured gases those measurements should be undertaken concurrently with this verification check.

3 For NDIR or NDUV - The potential for cross interferences effects of CO, CO_2, H_2O, CH_4 and SO_2 as applicable should be checked.

3.1 Apart from H_2O the interference species are dependent on the selected N_2O absorption band used by the device which should be known. From that knowledge good engineering judgement should be used to determine the interference gases to be used based on those which may be expected to be present in the exhaust gases to be measured.

4 For FTIR or LIA – The interference gases depend on the selected CH_4 or N_2O absorption band used by the device which should be known. Based on that knowledge, good engineering judgement should be used to determine the interference gases to be used.

5 The combined effect of the interference gases should not be more than 2% of the measured range or 2 ppm, whichever is the greater.

6 Verification procedure:

.1 the concentrations of the interference span gases as identified from paragraphs 3 or 4 of this appendix should be at least as high as the maximum values to be encountered in service. Those interference gases may be presented in the form of a multi-component span gas;

.2 the CH_4 or N_2O analyser is started, operated, zeroed and spanned as in service;

.3 humified interference test gas should be fed into the analyser. That test gas should be generated by bubbling the multi-component span gas through distilled H_2O in a sealed container. If the sample is not treated by a dryer the container temperature should be controlled to generate a H_2O concentration at least as high as the expected maximum when in service. If the sample is treated by a dryer the container temperature should be controlled to generate a H_2O concentration at least as high as the expected maximum based on the dryer outlet temperature when in service;

.4 the water mole fraction of the test gas should be determined from measurements taken as close as possible to the analyser inlet. Those measurements may be dew point and absolute pressure;

.5 condensation in the piping leading from the container generating the humidified test gas to the analyser should be minimized by maintaining an adequate minimum temperature; and

.6 following stabilization, the analyser output should be recorded for 30 seconds. The arithmetic mean response over that period should be compared with the limit in paragraph 5 of this appendix.

7 As an alternative to the multi-component span gas in paragraph 6 of this appendix, individual span gases may be run separately. In either case, where an interference gas concentration is higher than that to be measured in service the determined interference value should be scaled down by the ratio of in-service maximum / span concentration. Where the H_2O concentration is below that to be measured in service, but not below 0.025 % H_2O content, the determined interference may be scaled up by the ratio of maximum in-service value / the value used. The sum of the individual interferences should be compared with the limit in paragraph 5 of this appendix.

8 An interference verification check report documenting the procedure as followed, including the rational for the interference gases used and their concentrations, and the outcomes of that procedure is to be prepared and should be included in the CEMS record book.

9 Alternative approaches to the verification of CH_4 or N_2O analyser interference may be accepted if agreed to by the Administration. Where so used the justification for the approach taken should be included in the report as required by paragraph 8 of this appendix. Irrespective of the procedure followed, the limit given by paragraph 5 of this appendix remains applicable.

APPENDIX 4

EFFICIENCY OF THE NON-METHANE CUTTER (NMC)

1 The NMC is used for the removal of the non-methane hydrocarbons from the sample gas by oxidizing all hydrocarbons except CH_4. Ideally, the conversion rate for CH_4 is 0% and for the other hydrocarbons, as represented by ethane, C_2H_6, is 100%. Since a NMC may fail or performance deteriorate rapidly and without warning if operated outside certain ranges of gas concentrations and temperature ranges, the efficiency of the NMC should be checked as frequently as necessary to confirm that the requirements of paragraph 2 of this appendix are met. With the agreement of the Administration, alternative approaches to the assessment of NMC efficiency may be accepted.

2 Methane efficiency should not be more than 15%. Ethane efficiency should be at least 98%.

NMC methane efficiency

3 Methane calibration gas at a concentration typical of that to be measured is flowed through the FID analyser with and without the NMC bypassed. The methane efficiency, E_m, is determined as:

$$E_m = 1 - \frac{c_M\ (wCutter)}{c_M\ (w/oCutter)}$$

where:

c_M *(wCutter)*	HC concentration with CH_4 flowing through the NMC (ppmC1)
c_M *(w/oCutter)*	HC concentration with CH_4 bypassing NMC (ppmC1)

NMC ethane efficiency

4 Ethane calibration gas at a concentration typical of the expected non-methane hydrocarbon concentration to be measured is flowed through the FID analyser with and without the NMC bypassed. The ethane efficiency, E_e, is determined as:

$$E_e = 1 - \frac{c_E\ (wCutter)}{c_E\ (w/oCutter)}$$

where:

c_E *(wCutter)*	HC concentration with C_2H_6 flowing through the NMC (ppmC1)
c_E *(w/oCutter)*	HC concentration with C_2H_6 bypassing NMC (ppmC1)

APPENDIX 5

GUIDANCE ON THE INSTALLATION REQUIREMENTS FOR DEVICES TO MEASURE EXHAUST GAS VELOCITY

1 The determination of exhaust gas flow via direct measurement of mean exhaust gas velocity for an installed marine diesel engine is complex, owing to the fluid dynamic behaviour of that exhaust gas and the arrangement of the typical exhaust duct and associated devices such as exhaust gas boilers and silencers. Consequently, particular care should be taken to avoid errors in the measurement of that velocity across the load range – see paragraph 5.5.2.1 of the NTC 2008.

Objective definition

2 Prior to selecting a monitoring methodology, the objective of the direct measurement should be clearly communicated to the potential providers of the velocity measurement device in order to ensure methodological alignment.

3 A particular point to note is that for gases the viscosity increases as temperature increases, the converse to that experienced with liquids, hence the resulting flow profile in the engine's exhaust duct will alter over the engine's load range as the uptake exhaust gas temperature changes. A further point on this is where there are exhaust duct connections, such as wastegates / bypasses feeding in, or equipment such as exhaust gas boilers, extracting heat from the exhaust gas stream, a significant range of different exhaust gas temperatures can be encountered at the point of measurement for the same nominal engine load, noting additionally that where if engine can operate with a highly variable torque / speed profile, that in itself will be a another complicating factor.

4 Furthermore, if the device is to measure velocity when operating in both liquid only and dual-fuel modes there will be different exhaust gas compositions and hence densities.

Measurement requirements

5 Direct measurement of the mean velocity of the exhaust gas stream necessitates the following core components:

.1 preliminary investigation of the exhaust gas flow profiles across the engine's operating load range should be conducted either through validated in situ measurements or computational fluid dynamics (CFD) simulations, taking into account expected ranges of operating conditions and exhaust gas temperatures to be encountered; and

.2 mean velocity measurement at the designated sampling location.

6 Mean velocity may be derived from a series of point velocity measurements across the measurement plane or through alternative validated techniques. Measurement points should be distributed to represent regions of equal cross-sectional area. The selected measurement plane needs to be representative of the duct's volumetric flow rate and located in a region exhibiting uniform and stable flow characteristics.

APPENDIX 6

GUIDANCE ON THE DEVELOPMENT OF THE SCREENING AND REVIEW PROCEDURES AS REQUIRED BY SECTIONS 4.4 AND 4.12

1 The user of a CEMS as covered by these Guidelines should ensure, in accordance with section 4.12, that the intermediate calculated values and output data, as retained on the data recording device and as submitted to the Administration are, to the extent possible, correct. To that end, these Guidelines also require, in section 4.4, that the measured and input data is screened prior to use in the relevant calculation procedures as included in the CEMS file.

2 As given by these Guidelines, there are performance requirements in respect of the various measurement devices which should be met, in part that is demonstrated by the periodic checking or calibration of those devices. However, such devices may be subject to malfunction in service either as a result of problems with the measurement device itself or other factors such as its mounting or the transmission of the output signal. Similarly, input data may not have been correctly determined or could be subject to transcription errors through the reporting and entry processes.

3 Consequently, the CEMS file includes procedures which cover the screening (6.1.6.2) and review (6.1.6.6) activities. The particular nature and performance of these activities will depend on individual company processes and quality management procedures and hence it is not the intent of these Guidelines to detail such. Instead, the guidance as provided by this appendix is intended to assist users of CEMS in developing their particular procedures.

4 In this, there would be seen to be the:

.1 **initial data**, i.e. the data that is available and has been collected during commissioning of both the engine and the CEMS together with its supporting systems; and

.2 **ongoing data**, i.e. the data that is collected with the CEMS running.

5 In either case the same core point applies – if nothing changes the inputs, the outputs equally do not change. If there is a change in the outputs, is that level of change commensurate with the recorded changes to the inputs.

Initial data

6 From the factory acceptance test (FAT) of an engine and basic engineering experience, there should be a set of data available, augmented by in-service engine-room data logging, in terms of such parameters as fuel rates, both liquid and gas, operating pressures and temperatures across the load range.

7 In terms of the emission values and exhaust gas flow rates across the load range, there will be the Parent Engine test report as included the engine's approved technical file. Where the engine in question was either the Parent Engine or is an identical Member Engine to that Parent Engine, then the emission values and exhaust flow rates as given in that report provide a starting point for the emission values to be encountered in service. In some instances, CH_4 will have been measured (ppm) and quantified, for example in terms of methane slip – being the % of the methane based gas fuel which was present in the exhaust gas stream. Where CH_4 was not previously measured there will nevertheless be the

hydrocarbons (HC) reading – which for an engine using a methane based gas fuel will not be higher than the CH_4 value. Of course, where the test report is in respect of the NO_x certification requirements, then the engine's rating and NO_x critical components, settings / operating values will have been that combination which resulted in the highest NO_x values – one aspect of which is that the engine would have been tested with the highest liquid/gas fuel ratio, whereas the lower the liquid/gas fuel ratio the likelihood is that HC and CH_4 emission would have been higher. Of course, where the engine in question is not identical in some way to the Parent Engine, such as rating, number of cylinders, then due allowance would need to be applied as to how the Parent Engine test values related to that engine.

8 However, it would be seen that at the commissioning of a CEMS, which of necessity should be with the engine in operation, would be the time at which the initial benchmark of all to be measured values would be established across the load range.

9 In terms of the input values, for example those from a fuel testing service, engineering knowledge and experience should be applied to the values as received – and as entered into the CEMS system – most notably as to whether the units of a reported value are those as used by the CEMS system or is conversion first necessary. Similarly for the default values – are they correct, and in the units as used by the CEMS?

10 From these initial measured and input / default values then benchmark intermediate and final values would be determined and verified, as part of the CEMS commissioning process, as being as expected.

Ongoing data

11 There will be changes in the measured values at or around any particular load point over time due to differing influencing conditions, and this information should be used to build on the initial data. However, for the measured values, these should alter gradually as those influencing factors such as differing fuel qualities, wear, ambient conditions change over time. Hence, if there are any major differences in measured values due to, for example, a different engine management package being used – in contrast if there is a major change in just one measured value, then that may be indicative of a sensor malfunction – not ignoring that more than one sensor could fail / malfunction at the same time (as a result of a voltage spike?).

12 Similarly for the intermediate calculated values and final output data, there will be evolving changes – hence if there are major changes, jumps, in those values why? As before, are these due, for example, to a change in the engine management package or have the units of a particular input value have been incorrectly entered.

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ANNEX 19

REVISED WORK PLAN FOR THE DEVELOPMENT OF A REGULATORY FRAMEWORK FOR THE USE OF ONBOARD CARBON CAPTURE AND STORAGE (OCCS)

Goal: The goal of this work is to develop a regulatory framework for the use of onboard carbon capture and storage (OCCS), in order to reduce net GHG emissions from ships without negatively affecting the environment

Objectives: The work has the following objectives:

.1 avoiding emissions to air and discharges to sea that are harmful to the environment and ensuring traceability of the captured carbon;

.2 consider legal barriers that may hinder the use of OCCS and transportation and transfer of the captured carbon to safe permanent storage or utilization;

.3 facilitate access to certified reception facilities for the value chain for permanent storage or utilization of captured carbon;

.4 enable recording and reporting of relevant data; and

.5 develop options that take into account GHG emission reductions from onboard carbon capture in the IMO GHG regulatory framework.

Boundaries (freedoms and constraints):

.1 issues related to health, safety and the human element will be addressed by the Maritime Safety Committee (MSC) and its sub-committees. MSC and MEPC should liaise to ensure alignment of the overall regulatory framework for onboard carbon capture;

.2 issues related to accounting of emissions from ships using OCCS will be addressed by the workstreams on further development of the LCA framework, and decisions made in this process will affect the regulatory framework for OCCS;

.3 the regulatory framework should take a technology-neutral approach and needs to consider the diverse types of technology for OCCS;

.4 the regulatory framework needs to consider the environmental risks associated with the use of OCCS, and the transfer and discharge to shore; and

.5 decisions and developments in other workstreams related to the short-term and midterm GHG reduction measures may impact the work and should be considered.

Tasks:

.1 avoiding emissions to air and discharges to sea that are harmful to the environment and ensuring traceability of the captured carbon;

  .1 understand and identify the environmental risks of the different onboard carbon capture technologies;

  .2 develop measures to minimize the negative impact on the environment:

    .1 develop guidelines on testing, survey, and certification of OCCS, including development of provisions to minimize emissions/discharge of substances that are harmful to the environment and ensure the availability of the data needed for LCA calculations;

    .2 review the existing IMO regulatory framework in a structured manner to identify existing instruments that should be amended, and potential additional guidelines or regulations that may be needed; and

    .3 consider the need to define the acceptable means of disposal or use of captured carbon;

  .3 develop specific methodological guidance on OCCS accounting, verification, and certification, building upon the existing OCCS framework in the LCA Guidelines;

  .4 develop provisions for enforcement to ensure that the OCCS on ships comply with environment regulations and standards, including consideration of what existing regulations and guidelines need to be updated; and

  .5 review the status of technological development of onboard carbon capture applications, including their potential in reducing GHG emissions from ships;

.2 consider legal barriers that may hinder the use of OCCS and transportation and transfer of the captured carbon to safe permanent storage or utilization:

  .1 identify and understand the impact of any legal barriers; and

  .2 decide on further actions as appropriate;

.3 facilitate access to certified reception facilities for the value chain for permanent storage or utilization of captured carbon:

  .1 consider monitoring the development of relevant regulations applicable to facilities for permanent storage or utilization of captured carbon, carbon capture facilities, national regulations, and installation of OCCS on ships;

.2 consider if and how to address compatibility between ships and reception facilities ashore; and

.3 engage in a principal discussion on how to address the quality and concentration of the captured carbon delivered ashore;

.4 enable recording and reporting of relevant data:

.1 consider and identify what data should be recorded and reported and how;

.2 consider how to enable the traceability of the captured carbon; and

.3 update relevant guidelines and provisions as appropriate;

.5 develop options that take into account GHG emission reductions from onboard carbon capture in the IMO GHG regulatory framework:

.1 consider how GHG emission reductions achieved through OCCS could be reflected in the IMO regulatory framework; and

.2 update relevant guidelines as needed.

Timing: Aim to complete the work in 2028, and priority tasks as soon as possible. The tasks associated with objective 1 (tasks 1.1 to 1.5) should be prioritized.

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ANNEX 20

TERMS OF REFERENCE FOR THE FIFTH IMO GHG STUDY

Key definitions

Executive summary

PART 1 – GHG EMISSSIONS INVENTORY

1 Inventory of GHG emissions from international shipping 2018-2025[1]

1.1 Introduction and scope

1.1.1 The *2023 IMO Strategy on reduction of GHG emissions from ships* (resolution MEPC.377(80)) recalls that:

.1 the Third IMO GHG Study 2014 estimated that GHG emissions from international shipping in 2012 accounted for some 2.2% of global anthropogenic CO_2 emissions and that such emissions could grow by between 50% and 250% by 2050; and

.2 the Fourth IMO GHG Study 2020 estimated that GHG emissions from international shipping in 2018 accounted for some 2.89% of global anthropogenic GHG emissions and that such emissions could represent between 90% and 130% of 2008 emissions by 2050.

1.1.2 The 2023 IMO GHG Strategy also identifies that future annual IMO emission and carbon intensity estimates using the available data from the IMO Ship Fuel Oil Consumption Database (IMO DCS) and other relevant sources would help reduce the uncertainties associated with these emission estimates and scenarios.

1.1.3 The Fifth IMO GHG Study should be transparent, non-policy-prescriptive and include the issues described below.

1.1.4 The inventory should include current global emissions of GHGs and relevant substances emitted from ships of 100 GT and above engaged in international voyages as follows, breaking down the emissions at least in the size categories 100 – 399 GT; 400 – 4,999 GT; and 5,000 GT and above:

.1 GHGs should be defined as the six gases initially considered under the UNFCCC process: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), subject to data availability;

.2 other relevant substances that may contribute to climate change include:

.1 nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), particulate matter (PM) and sulphur oxides (SO_x), subject to data availability; and

[1] Where these terms of reference refer to 2025, potential bidders should also indicate their ability to provide emission estimates for the year 2026.

.2 Black Carbon (BC), subject to data availability and recognizing the complexity of providing accurate estimates;

.3 for the purpose of the emission estimates calculation of substances other than CO_2, the emission factors methodology presented in section 2.2.5 and annex B of the Fourth IMO GHG Study 2020 should be updated, taking into account the *Guidelines on life cycle GHG intensity of marine fuels* (LCA Guidelines), as appropriate; and

.4 the inventory should include total annual GHG emission[2] series from 2018 to 2025, or as far as statistical data are available.

1.1.5 Emission estimates should take into account the well-to-wake GHG emissions of marine fuels as addressed in the LCA Guidelines, with the understanding that the information provided would not prejudge the accounting of upstream and downstream emissions. Estimates should be provided for well-to-tank, tank-to-wake and well-to-wake GHG emissions.

1.1.6 Emission estimates should categorize emission sources to ensure that all types of tank-to-wake (TtW) emissions are comprehensively captured in accordance with the LCA Guidelines.

1.2 Differentiation between domestic and international voyages

1.2.1 The definitions set out in the Third IMO GHG Study 2014 are as follows:

"International shipping: shipping between ports of different countries, as opposed to domestic shipping. International shipping excludes military and fishing vessels. By this definition, the same ship may frequently be engaged in both international and domestic shipping operations. This is consistent with the IPCC 2006 Guidelines."

"Domestic shipping: shipping between ports of the same country, as opposed to international shipping. Domestic shipping excludes military and fishing vessels. By this definition, the same ship may frequently be engaged in both international and domestic shipping operations. This definition is consistent with the IPCC 2006 Guidelines."

1.2.2 The Fourth IMO GHG Study 2020 differentiated between domestic and international voyages according to two methods: the "voyage-based allocation" and the "vessel-based allocation" of emissions.

1.2.3 The Fifth IMO GHG Study should provide emission estimates using the same two methods and further develop clear and unambiguous definitions and refine methods for differentiation between domestic and international voyages with the aim to exclude domestic voyages from the inventory for "international shipping". This would mitigate the risk of the double counting of emissions from ships.

[2] Refer to paragraph 3.3.4 of the *2023 IMO Strategy on reduction of GHG emissions from ships* (resolution MEPC.377(80)).

1.3 Methods and data

1.3.1 The emission estimate should include a thorough review of the methodology and assumptions used in the inventory forming part of the Fourth IMO GHG Study 2020, taking into account peer-reviewed literature and other relevant literature sources to be determined in consultation with the Steering Committee undertaken since publication of the Fourth IMO GHG Study 2020. The review of the methodology and assumptions may be undertaken by the Steering Committee established by MEPC and/or by an expert group, as appropriate.

1.3.2 The emissions inventory is a technical exercise building on the methodology developed under the Second IMO GHG Study 2009, the Third IMO GHG Study 2014 and the Fourth IMO GHG Study 2020 and should be based on available data on fleet composition and size as well as on other technical ship particular data.

1.3.3 Analytical work should be based on available fleet and ship particular data, taking into account intellectual property rights as well as other relevant provisions.

1.3.4 Estimates should be determined by a top-down methodology such as fuel sales and shipping demand, and by a bottom-up (ship activity) methodology. The bottom-up methodology should be subject to data availability and following the methodology and assumptions used in the Second, Third and Fourth IMO GHG Studies, but consider methodological developments in peer-reviewed literature and other relevant literature sources to be determined in consultation with the Steering Committee. This should be complemented by data derived from all relevant sources, including the IMO DCS, to reduce the uncertainties associated with emission estimates. The bottom-up estimate should be compared with the top-down estimate and any discrepancy analysed and explained, as far as possible.

1.3.5 IMO DCS data, generally being a reliable source of actual operational data, albeit with limited coverage, should serve as a benchmark for data calibration purposes particularly for individual ships. The Fifth Study should develop methodologies and approaches to compare and evaluate data from various sources against this benchmark; and explore possible approaches for resolving the misalignment in GHG emissions between the DCS data and bottom-up estimates.

1.3.6 Ship type and size categories should be aligned, as far as possible, with those used in MARPOL Annex VI, in particular for the application of the short-term GHG reduction measure, although for comparability purposes those used in the Fourth IMO GHG Study may also be considered.

1.4 Outcome

Results should be compared and discussed with the aim of identifying an estimate for GHG emissions from international shipping and from shipping as a whole on an annual basis from 2018 to 2025.

2 Estimates of GHG fuel intensity

2.1 The Fifth IMO GHG Study should provide estimates of the world fleet's GHG fuel intensity from 2018 to 2025, or as far as statistical data are available, using the data consistent with the outcome of the inventory estimates.

2.2 The estimates for GHG fuel intensity should be provided for well-to-tank, tank-to-wake, and well-to-wake phases, using the methodologies and parameters specified in the LCA Guidelines.

3 Estimates of carbon intensity

3.1 Carbon intensity estimates for the years 2018-2025

3.1.1 The Fifth IMO GHG Study should provide estimates of the world fleet's CO_2 emissions and energy consumed (MJ) per transport work,[3] from 2018 to 2025 or as far as statistical data are available, using the outcome of the inventory estimates.

3.1.2 Carbon intensity indicators should be estimated using parameters consistent with the IMO DCS, as relevant, for the various ship types. Other potential indicators are also suggested to be estimated as far as statistical data are available, including additional reporting parameters to the IMO DCS.

3.1.3 In order to better understand the reduction in emissions that are a result of changing fuels and those that have come about via improvements in the energy efficiency of ships, the Fifth IMO GHG Study should also include estimates of the energy consumed (MJ) per transport work from 2018 to 2025 or as far as statistical data are available.

3.1.4 Carbon intensity estimates for 2018 to 2025-should specifically demonstrate progress towards the level of ambition set out in the 2023 IMO GHG Strategy to achieve at least a 40% reduction of carbon intensity by 2030 compared to 2008. The estimates of the carbon intensity of international shipping for the year 2008, as set out in the Fourth IMO GHG Study, should be used as a reference for these purposes.

3.1.5 The Fifth Study should also provide a comparison of the carbon intensity of shipping with other transport modes, subject to data availability and recognizing the complexity of providing accurate estimates.

4 Estimates of energy consumed and WtW emissions for the year 2008

4.1 The Fifth IMO GHG Study should estimate the energy consumed (MJ) by international shipping and shipping as a whole for the year 2008, using data from the Fourth IMO GHG Study.

4.2 The Fifth IMO GHG Study should estimate the WTW GHG emissions of international shipping and shipping as a whole for the year 2008, using data from the Fourth IMO GHG Study.

PART 2 – GHG EMISSIONS PROJECTIONS

5 Scenarios for future international shipping emissions 2025-2050

5.1 Introduction

5.1.1 The Fifth IMO GHG Study should develop business-as-usual emission scenarios[4] on the basis of all plausible combinations of representative concentration pathways (RCPs) and shared socio-economic pathways (SSPs), and discuss their plausibility in the light of recent peer-reviewed scientific literature and GDP growth projections made by international economic organizations. In addition, the Study should develop business-as-usual emission scenarios on the basis of one or more recent GDP growth projections made by international economic organizations, e.g. the OECD, IMF, World Bank.

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[3] Refer to paragraph 3.3.2 of the *2023 IMO Strategy on reduction of GHG emissions from ships* (resolution MEPC.377(80)).

[4] "Business-as-usual emission scenarios" assume that the current IMO policies-on GHG emissions of ships remain as they are in force at the time of awarding the contract.

5.1.2 The Fifth IMO GHG Study should project transport demand and shipping emissions up to 2050.

5.2 Methods and data

5.2.1 In developing future scenarios that affect emissions from international shipping, the Fifth IMO GHG Study should take fully into account the application of relevant adopted IMO regulations and other industry measures to re-evaluate the status of GHG emissions from shipping. Updated Marginal Abatement Cost Curves (MACCs) taking into account recent and projected technology and economic trends, as well as both regionally-appropriate technology and any constraints on regional availability of technology, in shipping should be developed as technical information for reference.

5.2.2 All modelling approaches should be transparent in their parameters; methodological and modelling choices as well as assumptions should be clearly described so as to make the study replicable; and should be accompanied by sensitivity analysis.

5.3 Outcome

5.3.1 Results should be compared and discussed with the aim of identifying, as far as possible, trends for GHG emissions and carbon intensity from international shipping and from shipping as a whole between 2025 and 2050.

5.3.2 In addition to providing updated GHG emissions projections, the Fifth Study should also provide updated maritime transport demand projections and associated energy consumption projections of the world fleet.

5.3.3 Projections should take into account the well-to-wake GHG emissions of marine fuels as addressed in the LCA Guidelines with the understanding that the information provided would not prejudge the accounting of upstream and downstream emissions. Projections should be provided for well-to-tank, tank-to-wake and well-to-wake GHG emissions.

5.3.4 The presentation of results should include trends in absolute GHG emissions in well-to-wake emissions accountancy, ″carbon intensity″ as currently conceived, and energy (MJ). Where results explain/attribute these trajectories to uptake or changes in technology, fuel and operation, these should be clearly demarcated as changes in GHG intensity of energy used on board, and changes in energy efficiency of the ship.

5.3.5 Results should be disaggregated breaking down the emissions at least in the size categories 100 – 399 GT; 400 – 4,999 GT; and 5,000 GT and above.

PART 3 – GENERAL PROVISIONS

Transparent access to the underlying data

Subject to limitations imposed by contracts, and consistent with existing provisions in regulations on DCS data accessibility, disaggregated output data used in the Fifth IMO GHG Study's analysis, which underpins its conclusions, should be made available to the public in an anonymized, accessible, and machine-readable format.

Bibliography

Organizational matters

Responsibility of the authors

While taking into account relevant new information, the authors should not duplicate existing studies that have already been completed. Therefore, in conducting the Fifth IMO GHG Study, the authors should consult a broad range of reputable organizations, institutions and resources with relevant experience and/or expertise within areas of the terms of reference. The authors should validate the credibility of the information obtained. The responsibility for the content of the Study would rest with the authors.

Steering Committee

A Steering Committee should be established by the Committee at its eighty-fourth session. It should be geographically balanced (e.g. referring to the five UN regions); equitably represent developing and developed countries; include relevant stakeholders; and should be of a manageable size (therefore, as small as possible).

The Steering Committee should:

.1 act as a focal point for the Committee;

.2 provide input into the tendering process and approve the Study outline;

.3 conduct an external review of quality assurance and quality control (QA/QC) issues in the final report before it is submitted to MEPC 87, consulting experts chosen by members of the Steering Committee and taking into account suggestions of independent experts and academic and research institutions proposed by Member States and observers; and

.4 confirm that the Study meets the terms of reference, and review and monitor its progress.

The Steering Committee should, as far as possible, take decisions by consensus, make all efforts to ensure the timely completion of the Study and undertake most of its work using modern communication methods, e.g. email and teleconferencing.

Consortium selection process

The selection of the consortium responsible for carrying out the Fifth IMO GHG Study should be carried out through a transparent and competitive formal solicitation process. The terms of reference shall specify that this process will invite proposals from qualified research institutions, academic bodies, and industry experts, consultancies and other organizations with relevant expertise. The solicitation will clearly define the Study's requirements, expected deliverables, timeline, and evaluation criteria. This approach will ensure that the selected consortium possesses the necessary expertise, resources, and impartiality to undertake a comprehensive and credible Study, thereby maximizing the quality and reliability of the Fifth IMO GHG Study.

Quality assurance and quality control

The contractor should put in place robust internal quality assurance and quality control processes and tenderers should provide full details of these processes in their bids.

Contract and implementation

The Secretariat will be responsible for procuring the services of the contractor(s) by [30 September 2026] and supervising the execution of the Fifth IMO GHG Study. IMO's General Terms and Conditions will be applicable to the contract(s). If the tenderer intends to subcontract part of the work or to carry out the work in cooperation with another partner, full details will have to be given in the bid. Overall responsibility for the work will remain with the contractor(s).

All payments will be made in US dollars and therefore quotes should be provided in that currency. If any currency conversions are required, the rate of exchange will be the official United Nations operational rate applicable on the date of payment.

In line with IMO's General Terms and Conditions, Staff Regulations and Rules, Financial Regulations and Rules and Procurement Policies, contractor(s) and subcontractor(s) should avoid administrator and staff conflicts of interest and should have policies in place that prevent staff, board members, consultants and management from having financial, commercial or fiduciary conflicts of interest in relation to the development of and provision of services related to the Fifth IMO GHG Study.

Delivery

The final report of the Fifth IMO GHG Study should be submitted to the eighty-seventh session of the Marine Environment Protection Committee, expected to be held in spring 2028.

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