Subject

Summary of the outcomes of MEPC 77

ClassNK
Technical Information

No. TEC-1259
Date 1 March 2022

To whom it may concern

The seventy-seventh session of the Marine Environment Protection Committee (MEPC 77) was held from 22 to 26 November 2021.
A summary of the discussions and the decisions taken at MEPC 77 is provided as below for your information.

1. Greenhouse Gases (GHG) emission reduction measures
Measures to reduce GHG emissions from international shipping have been deliberated at IMO, and so far, the Energy Efficiency Design Index (EEDI), the Ship Energy Efficiency Management Plan (SEEMP) and the Data Collection System for fuel oil consumption of ships (DCS) were introduced. Further, at MEPC 72 held in April 2018, the Initial IMO Strategy on the reduction of GHG emissions from ships, which includes the emission reduction target and the candidate measures to reduce GHG emissions, was adopted.

(1) Short-term measures for reduction of GHG
The initial IMO Strategy on the reduction of GHG emissions from ships specifies the short-term target by 2030 for improved transportation efficiency of at least 40% compared to 2008. To achieve the short-term target, at MEPC 76, the amendments to MARPOL Annex VI were adopted to implement Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) as well as the related Guidelines were also adopted. Further, a Correspondence Group (CG) was established for the implementation of CII framework to develop/update Guidelines on SEEMP and DCS, correction factors for certain ship types for the CII calculations.
An interim report of the CG was submitted at this session and followings were agreed. For finalization of the above-mentioned Guidelines, CG will continue its work and final report of the CG will be submitted to MEPC 78.

- in cases where a ship holds multiple load line certificates, deadweight and/or gross tonnage to be used for calculation of the CII should be specified in DCS verification guidelines
- the correction factors should be applied in the calculation of the attained CII, and the CII value after correction should be used for rating purposes
- the attained annual operational CIIs as well as the parameters to calculate the correction factors etc. should be reported to IMO

(To be continued)

(2) Mid/Long-term measures for reduction of GHG

The initial IMO Strategy on the reduction of GHG emissions from ships specifies the middle-term target by 2050 to pursue the efforts towards the CO_2 reduction of 70% per transport work and to reduce the total annual GHG emissions by at least 50% as well as the long-term target within this century to aims to phase out GHG emissions as soon as possible.

At this session, proposals for mid/long-term measures to achieve the above target were submitted, such as cap-and-trade system, carbon levy etc. These proposals will be further considered at future session.

(3) IMRF and IMRB

At MEPC 75 held in November 2020, to promote research and development of low and decarbonized technologies, it was proposed to establish the International Maritime Research Fund (IMRF). As a result of the discussion, MEPC 77 agreed to continuously consider this proposal at the future sessions.

(4) Review of Initial IMO Strategy on the reduction of GHG emissions from ships

In order to keep the Paris Agreement temperature goals which would limit temperature rise in 2100 to 1.5ºC, the recent reports of the Intergovernmental Panel on Climate Change (IPCC) emphasize the urgency of tackling the climate crisis and reinforce that all emissions must peak now and a zero GHG emissions level must be achieved for all sectors by at least 2050.

At this session, recognizing the need to strengthen the ambition of Initial IMO Strategy, MEPC 77 agreed to conduct a revision of the Initial IMO Strategy, with a view to finalization at MEPC 80 to be held in Spring 2023.

(5) Wind Assisted Propulsion Systems on EEDI

At MEPC 65 held in May 2013, Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI (MEPC.1/Circ.815) was approved to incorporate the effect of innovative technologies into the calculation of EEDI values.

At this session, the amendments to MEPC.1/Circ.815 were approved to reflect the effect of the Wind Assisted Propulsion Systems (WAPS) to EEDI/EEXI calculation.

(Refer to the attachment 4: MEPC.1/Circ.896)

(To be continued)

2. BWM Convention

(1) Commissioning of Ballast Water Management Systems

At MEPC 75 held in November 2020, the amendments to the BWM Convention were adopted to specify the requirements to conduct a commissioning test of Ballast Water Management System (BWMS) including sampling and analysis. This amendment will enter into force on 1 June 2022.

At this session, an Unified Interpretation was approved to interpret that the commissioning testing of individual BWMS should be conducted if the initial or additional survey is completed on or after 1 June 2022.

(Refer to the attachment 5: BWM.2/Circ.66/Rev.2)

(2) Ships operating at ports with challenging water quality

Proposals on application of the BWM Convention to ships operating at ports with challenging water quality was made due to concerns on operation of BWMS at port area where certain water qualities, such as high level of turbidity, high level of total suspended solids or low salinity, are identified to exceed the operational limitation.

At this session, it was agreed to treat the cases where ships operate at ports with challenging water quality as contingency measures specified in BWM.2/Circ.62. MEPC 77 also agreed to further consider the matter at next session to develop the guidance for ships operating at ports with challenging water quality.

(3) Experience-building phase

At MEPC 71 held in October 2017, MEPC resolution was adopted, which stipulates a work plan during the experience-building phase (EBP) to gather data and analyze the concerns for implementation of the BWM Convention and to facilitate the implementation of the Convention by classifying EBP into three stages as follows.

Stage 1: data gathering to collect the concerns over the implementation of the Convention
Stage 2: data analysis
Stage 3: review of the requirements of the Convention

At this session, the extension of EBP was proposed due to the delay in the data gathering caused by the pandemic of COVID-19. As a result of the discussion, MEPC 77 agreed to consider a possibility of the extension at next session, in which the result of data analysis based on the gathered data will be reported.

(To be continued)

3. Air pollution

(1) Guidelines for Exhaust Gas Cleaning System (EGCS)

Regulation 14 of MARPOL Annex VI prescribes requirements of sulphur content of any fuel oil used on board ships, for reduction of SOx emission from international shipping, and alternative compliance method can be applied with acceptance of the Administration in accordance with regulation 4 of Annex VI. Under the circumstances that the Exhaust Gas Cleaning System (EGCS) is used as alternative compliance methods, EGCS should be in line with EGCS Guidelines (MEPC.289(68)), which stipulate the technical standards and verification procedures.

At this session, based on the reports from PPR Sub-Committee, amendments to the EGCS Guidelines, which include new definitions for technical terms and revision of technical standards, etc., were adopted. The guidelines will be applied to EGCS installed on ships the keels of which are laid or which are at a similar stage of construction on or after 1 June 2022; or exhaust gas cleaning systems installed on ships the keels of which are laid or which are at a similar stage of construction before 1 June 2022 which have a contractual delivery date of EGCS to the ship on or after 1 June 2022 or, in the absence of a contractual delivery date, the actual delivery of the exhaust gas cleaning system to the ship on or after 1 June 2022; or amendments, as those specified in paragraphs 4.2.2.4 or 5.6.3 of the 2021 EGCS Guidelines, to existing exhaust gas cleaning systems undertaken on or after 1 June 2022.

(Refer to the attachment 1: Res. MEPC.340(77))

(2) Failure of EGCS

At MEPC 74, the Guidance on recommended actions to take in the case of the failure of a single monitoring instrument and the EGCS fails etc. was adopted. The Guidance specifies the procedures that a short-term temporary emission exceedance due to the system response should not be considered as a breach, and the system malfunction that cannot be rectified within one hour is regarded as a breakdown. Also, any EGCS malfunction that lasts more than one hour or repetitive malfunctions is required to be reported to flag States and port State's Administration to determine the appropriate action. At their discretion, the Flag State could take such information and other relevant circumstances into account to determine the appropriate action to take in the case of an EGCS malfunction.

At this session, amendments to the Guidance were approved to require additional communication with the relevant port State to decide on appropriate action in accordance with the Convention, to continue on its intended voyage in a non-compliant condition.

(Refer to the attachment 3: MEPC.1/Circ.883/Rev.1)

(To be continued)

4. Others - Marine plastic litter -

   With a view to tackling the problem of plastics in the oceans, MARPOL Annex V prohibits discharge of plastics from vessels. However, it was often pointed out that this prohibition regulation was not effective and that some additional actions were needed at IMO level to reduce plastic pollution in the marine environment. To solve this problem, it was agreed to conduct IMO study on marine plastic litter from ships to estimate the contribution to marine plastic litter by all ships.

   At this session, MEPC resolution on Strategy to Address Marine Plastic Litter from Ships was adopted, which includes vision of aims to strengthen the international framework and compliance with the relevant IMO instruments, endeavoring to achieve zero plastic waste discharges to sea from ships by 2025.

   (Refer to the attachment 2: Res. MEPC.341(77))

A summary of the outcomes of MEPC 77 is also available on the IMO website.
https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MEPC-default.aspx

For any questions about the above, please contact:

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Attachment:

1. Res. MEPC.340(77)
2. Res. MEPC.341(77)
3. MEPC.1/Circ.883/Rev.1
4. MEPC.1/Circ.896
5. BWM.2/Circ.66/Rev.2

ANNEX 1

RESOLUTION MEPC.340(77)
(adopted on 26 November 2021)

2021 GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

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

RECALLING ALSO that, at its fifty-eighth session, the Committee adopted, by resolution MEPC.176(58), a revised MARPOL Annex VI which significantly strengthens the emission limits for sulphur oxides (SO_X),

NOTING that regulation 4 of MARPOL Annex VI allows the use of an alternative compliance method at least as effective in terms of emission reductions as that required by the Annex, including any of the standards set forth in regulation 14, taking into account guidelines developed by the Organization,

RECALLING that, at its fifty-ninth session, the Committee adopted, by resolution MEPC.184(59), the *2009 Guidelines for exhaust gas cleaning systems*,

RECALLING ALSO that, at its sixty-eighth session, the Committee adopted, by resolution MEPC.259(68), the *2015 Guidelines for exhaust gas cleaning systems* (hereinafter referred to as the "2015 EGCS Guidelines"),

RECOGNIZING the need to update the 2015 EGCS Guidelines,

HAVING CONSIDERED, at its seventy-seventh session, draft amendments to the 2015 EGCS Guidelines, prepared by the Sub-Committee on Pollution Prevention and Response at its seventh session,

1 ADOPTS the *2021 Guidelines for exhaust gas cleaning systems* (hereinafter referred to as the "2021 EGCS Guidelines"), as set out in the annex to the present resolution;

2 INVITES Administrations to implement the 2021 EGCS Guidelines and apply them to exhaust gas cleaning systems installed on ships the keels of which are laid or which are at a similar stage of construction on or after 1 June 2022; or exhaust gas cleaning systems installed on ships the keels of which are laid or which are at a similar stage of construction before 1 June 2022 which have a contractual delivery date of EGCS to the ship on or after 1 June 2022 or, in the absence of a contractual delivery date, the actual delivery of the exhaust gas cleaning system to the ship on or after 1 June 2022; or amendments, as those specified in paragraphs 4.2.2.4 or 5.6.3 of the 2021 EGCS Guidelines, to existing exhaust gas cleaning systems undertaken on or after 1 June 2022, when allowing the use of an exhaust gas cleaning system in accordance with regulation 4 of MARPOL Annex VI;

3 REQUESTS Parties to MARPOL Annex VI and other Member Governments to bring the 2021 EGCS Guidelines to the attention of shipowners, ship operators, shipbuilders, marine diesel engine manufacturers and any other interested groups;

4 INVITES Administrations to provide for discharge water data collection as described in appendix 3 of these Guidelines, and to also apply that appendix when undertaking related sampling from exhaust gas cleaning systems that have been approved in accordance with the earlier versions of the EGCS Guidelines;

5 AGREES to keep these Guidelines under review in the light of experience gained with their application; and

6 ALSO AGREES that these Guidelines supersede the 2015 EGCS Guidelines adopted by resolution MEPC.259(68).

ANNEX

2021 GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

1 INTRODUCTION

1.1 MARPOL Annex VI requires ships to use fuel oil with a sulphur content not exceeding that stipulated in regulations 14.1 or 14.4. Regulation 4 allows, with the approval of the Administration, the use of an alternative compliance method at least as effective in terms of emission reductions as that required by the Annex, including the standards set forth in regulation 14. The Administration of a Party should take into account any relevant Guidelines developed by the Organization pertaining to alternatives provided for in regulation 4.

1.2 These Guidelines have been developed to allow for the testing, survey, certification, and approval of Exhaust Gas Cleaning Systems (EGCSs) in accordance with regulation 4 of MARPOL Annex VI.

1.3 Equivalency with the relevant requirements of regulation 14 of MARPOL Annex VI should be demonstrated by using these Guidelines as a basis of compliance with the relevant Emission Ratio limit value as given in table 1. Where the design or operation of an EGCS requires controls in addition to those given in these Guidelines in order to meet the requirements of regulation 4.4 of the above-mentioned Annex, they should be subject to special consideration by the Administration and should be communicated to the Organization when submitting the notification required by regulation 4.2 of MARPOL Annex VI.

Table 1: Fuel oil sulphur limits in regulations 14.1 and 14.4 and corresponding Emission Ratio limit values

Fuel oil sulphur content (% m/m)	Emission Ratio SO_2(ppm)/CO_2(% v/v)
0.50	21.7
0.10	4.3

Note: The use of the above Emission Ratio limit values is only applicable when using petroleum-derived distillate or residual fuel oils. See appendix 2 for the assumptions and rationale which form the basis of the Emission Ratio method.

1.4 These Guidelines are recommendatory in nature; however, Administrations are invited to base the implementation of the relevant requirements of regulation 4 of MARPOL Annex VI on them.

2 GENERAL

2.1 Purpose

2.1.1 The purpose of these Guidelines is to specify the criteria for the testing, survey, certification and verification of EGCSs under regulation 4 of MARPOL Annex VI to ensure that they provide in service, at any operating load point at which they are to operate, including during transient operation, effective equivalence to the requirements of regulations 14.1 or 14.4 of MARPOL Annex VI, as applicable.

2.1.2 These Guidelines describe two schemes for approval of an EGCS: Scheme A (system certification with in-service continuous operational parameter monitoring and periodic emission checks) and Scheme B (continuous emission monitoring by means of an approved monitoring system together with periodic operational parameter checks):

.1 in Scheme A, the EGCS is subject to approval by the Administration and should be as given in section 4 subject to performance tests, sea trials or other similar physical tests that verify that the system in service will result in the intended performance; and

.2 in Scheme B, the exhaust gas monitoring system of the EGCS is subject to approval by the Administration and should be as given in section 5. Approved exhaust gas monitoring system should continuously indicate the Emission Ratio while the EGCS is in operation, allowing verification against the applicable limit.

2.1.3 Emission testing in relation to either Scheme A or Scheme B should be undertaken, as appropriate, as given in section 6.

2.1.4 Data recording, retention and the preparation of reports using that data in relation to either Scheme A or Scheme B should be, as appropriate, as given in section 7.

2.1.5 Details of the monitoring systems for exhaust emissions, operating parameters, inlet water, washwater and discharge water in relation to either Scheme A or Scheme B should be documented, as appropriate, as given in section 8.

2.1.6 For ships which are to use an EGCS in part or in total as an approved equivalent to the requirements of regulations 14.1 and/or 14.4 of MARPOL Annex VI, there should be an approved SO_X Emissions Compliance Plan (SECP) as given in section 9.

2.1.7 Discharge water monitoring which is equally applicable to Scheme A and Scheme B should be undertaken as given in section 10.

2.2 Application

2.2.1 These Guidelines apply to any EGCS as applied to fuel oil combustion unit(s), excluding shipboard incinerators, installed on board a ship.

2.2.2 For the purpose of these Guidelines, the term "EGCS" should be generally, but not exclusively (see 2.2.3), understood as "wet EGCS".

2.2.3 In the absence of specific guidelines for EGCSs which use technologies or operate in modes that are not defined in 2.3, these Guidelines may also be applied as appropriate.

2.2.4 These Guidelines apply to:

.1 EGCSs installed on ships the keels of which are laid or which are at a similar stage of construction on or after 1 June 2022; or

.2 EGCSs installed on ships the keels of which are laid or which are at a similar stage of construction before 1 June 2022 which have a contractual delivery date of EGCS to the ship on or after 1 June 2022 or, in the absence of a contractual delivery date, the actual delivery of the EGCS to the ship on or after 1 June 2022; or

.3 amendments as those specified in 4.2.2.4 or 5.6.3 to existing EGCSs undertaken on or after 1 June 2022.

2.3 Abbreviations, definitions and required documents

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

Table 2: Abbreviations

CL	Closed-Loop
CO_2	Carbon dioxide
EGC	Exhaust gas cleaning
EGCS	Exhaust gas cleaning system
ETM-A	EGCS – Technical Manual for Scheme A
ETM-B	EGCS – Technical Manual for Scheme B
MCR	Maximum Continuous Rating
SECP	SO_X Emissions Compliance Plan
SECC	SO_X Emissions Compliance Certificate
SO_2	Sulphur dioxide
SO_X	Sulphur oxides
OL	Open-Loop
OMM	Onboard Monitoring Manual
PAH	Polycyclic Aromatic Hydrocarbons
PAH_{phe}	Polycyclic Aromatic Hydrocarbons as phenanthrene equivalents (see table 3)
UTC	Universal Time Coordinated

Table 3: Definitions

12-hour period	A period of 12 consecutive hours determined on a rolling basis with new 12-hour periods beginning past each hour of EGCS operation.
Bleed-off water	An amount of aqueous solution removed from the washwater of an EGCS operating in closed-loop mode to keep its required operating properties and efficiency.
Certified Value	The Emission Ratio specified by the manufacturer that the EGCS is certified as meeting when operating on a continuous basis on the manufacturer-specified maximum fuel sulphur content and within the specified operational parameters. Applicable to Scheme A only.
Closed-loop mode	EGCS operating mode in which the washwater is passed several times through the EGC unit.

	In order for the washwater to keep its required operating properties and efficiency, its pH usually has to be adjusted, e.g. by adding chemicals such as NaOH. In addition, a small amount of washwater is bled, periodically or continuously, from the system. This bleed-off water, unless meeting discharge water criteria, needs to be treated to meet discharge water criteria, or is regarded as EGCS residue.
Continuous monitoring	Process and technology used for evaluation of EGCS compliance through representative measurement, at a specified frequency, for selected parameters.
Discharge water	Any water from an EGCS to be discharged overboard.
EGC unit	Device within which exhaust gas and cleaning medium are mixed. An EGC unit may have a single or multiple fuel oil combustion unit(s) connected to it.
EGCS Electronic Data Recording, or Electronic Logging System	Automatic record of the EGCS in service operating parameters. The record of parameters does not involve any user input.
EGCS Record Book (or Electronic Record Book)	A user-input record of the EGCS, component adjustments, corrective and planned maintenance and service records as appropriate. It can have an electronic format.
EGCS residue	Material removed from the washwater or the bleed-off water by a treatment system or discharge water that does not meet the discharge criterion, or other residue material removed from the EGCS.
Emission Ratio	SO_2 expressed in ppm/CO_2 expressed in % v/v.
Exhaust Gas Cleaning System (EGCS)	A system that includes one or more EGC units and which is based on technology that uses a wet cleaning medium for the reduction of SO_X from an exhaust gas stream from installed fuel oil combustion unit(s), operating in either open-loop or closed-loop mode. A hybrid EGCS can operate in both open-loop mode and closed-loop mode. Several EGC units may utilize a common uptake system with a single exhaust gas monitoring system. Several EGC units may utilize a common washwater, water supply, treatment and/or overboard system and discharge water monitoring equipment.
Extractive sampling system	System which extracts a sample flow from the exhaust gas stream and transfers it by heated lines to the measurement instrument.
Fuel oil combustion unit	Any engine, boiler, gas turbine, or other fuel oil fired equipment, excluding shipboard incinerators.
Inlet water	Water entering the ship as a cleaning medium for an EGC unit.
In situ	Measuring directly within an exhaust gas stream.

Load range	Interval ranging from minimum practicable to maximum rated power of diesel engine or maximum steaming rate of the boiler.
Open-loop mode	EGCS operating mode in which the washwater, typically seawater, is passed through the EGC unit only once before it is being discharged overboard as discharge water.
Phenanthrene equivalent	It corresponds to the signal produced by a PAH monitor with excitation wavelengths between 244 nm and 264 nm (254±10 nm) and detection wavelengths between 310 nm and 410 nm (360±50 nm) calibrated against a known set of phenanthrene concentrations within the expected measurement range when exposed to EGCS discharge water containing a range of different PAH species.
Washwater	Cleaning medium brought into contact with the exhaust gas stream for the reduction of SO_X.
Wet EGCS	EGCS using liquid cleaning medium.

2.3.2 Relevant documents for EGCSs approved in accordance with Scheme A and Scheme B are listed in table 4.

Table 4: Relevant documents for Scheme A and Scheme B

Document	Scheme A	Scheme B
SECP	X	X
SECC	X	
ETM Scheme A	X	
ETM Scheme B		X
OMM	X	X
EGCS Record Book or Electronic Record Book	X	X

3 SAFETY NOTE

3.1 Due attention is to be given to the safety implications related to the handling and proximity of exhaust gases, the measurement equipment and the storage and use of pressurized containers of pure and calibration gases. Sampling positions and permanent access platforms should be such that this monitoring may be performed safely. For positioning the EGCS discharge water outlet, due consideration should be given to the locations of the existing seawater inlets. In all operating conditions the design of the EGCS should take into consideration the necessary balance between low pH water discharge and the anti-corrosive resistance of the surfaces in contact with that discharge stream. To avoid premature failure of sea chests, discharge pipework and hull penetration finishes, due care should be taken in the preparation of surfaces and the correct selection and application of protective coatings to withstand the corrosive effects of low pH discharge water.

3.2 In cases where exhaust gas duct bypass lines are arranged on board, appropriate measures should be taken to prevent leakage of exhaust gases from the damper to bypass lines.

4 SCHEME A – EGCS APPROVAL, SURVEY AND CERTIFICATION USING PARAMETER AND EMISSION CHECKS

4.1 Approval of EGCSs

4.1.1 General

Options under Scheme A of these Guidelines provide for:

.1 individual EGCS approval;

.2 serially manufactured systems; and

.3 production range approval.

4.1.2 Individual EGCS approval

4.1.2.1 An EGCS should be certified as capable of meeting the Emission Ratio value, the Certified Value, specified by the manufacturer (e.g. the Emission Ratio value the system is capable of achieving on a continuous basis) with fuel oils of the manufacturer's specified maximum % m/m sulphur content and for the range of operating parameters, as listed in 4.2.2.1.2, for which they are to be approved. The Certified Value should at least be suitable for ship operations under requirements given by MARPOL Annex VI regulations 14.1 and/or 14.4.

4.1.2.2 Where testing is not to be undertaken with fuel oils of the manufacturer's specified maximum % m/m sulphur content, the use of two test fuels with a lower % m/m sulphur content is allowed. The two fuels selected should have a difference in % m/m sulphur content sufficient to demonstrate the operational behaviour of the EGCS and to demonstrate that the Certified Value can be met if the EGCS were to be operated with a fuel of the manufacturer's specified maximum % m/m sulphur content. In such cases a minimum of two tests, in accordance with subsection 4.3 as appropriate, should be performed. These tests need not be sequential and could be undertaken on two different, but identical, EGCSs.

4.1.2.3 The maximum and, if applicable, minimum exhaust gas mass flow rate of the system should be stated. The effect of variation of the other parameters defined in 4.2.2.1.2 should be justified by the equipment manufacturer. The effect of variations in these factors should be assessed by testing or otherwise as appropriate. No variation in these factors, or combination of variations in these factors, should be such that the emission value of the EGCS would be in excess of the Certified Value.

4.1.2.4 Data obtained in accordance with this section should be submitted to the Administration for approval together with the ETM-A.

4.1.3 Serially manufactured systems

4.1.3.1 In the case of nominally similar EGCSs of the same mass flow ratings as that certified under 4.1.2, and to avoid the testing of each EGCS, the Administration, based on a submission of the equipment manufacturer, should take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production arrangement. The certification of each EGCS under this arrangement should be subject to such surveys that the Administration should consider necessary as to assure that each EGCS has an Emission Ratio value of not more than the Certified Value when operated in accordance with the parameters defined in 4.2.2.1.2.

4.1.4 Product range approval

4.1.4.1 In the case of an EGCS of the same design, but of different maximum exhaust gas mass flow capacities, the Administration may accept, in lieu of tests on an EGCS of all capacities in accordance with 4.1.2, tests of EGCSs of three different capacities provided that the three tests are performed at intervals including the highest, lowest and one intermediate capacity rating within the range.

4.1.4.2 Where there are significant differences in the design of EGCSs of different capacities, this procedure should not be applied unless it can be shown, to the satisfaction of the Administration, that in practice those differences do not materially alter the performance between the various EGCS types.

4.1.4.3 For EGCSs of different capacities, the sensitivity to variations in the type of combustion machinery to which they are fitted should be detailed together with sensitivity to the variations in the parameters listed in 4.2.2.1.2. This should be on the basis of testing, or other data as appropriate.

4.1.4.4 The effect of changes of EGCS capacity on washwater and discharge water characteristics should be detailed.

4.1.4.5 All supporting data obtained in accordance with this section, together with the ETM-A for each system, should be submitted to the Administration for approval.

4.2 Survey and certification

4.2.1 Procedures for the certification of an EGCS

4.2.1.1 In order to meet the criterion of subsection 4.1 either prior to, or after installation on board, each EGCS should be certified as meeting the Certified Value specified by the manufacturer (e.g. the Emission Ratio the system is capable of achieving on a continuous basis) under the operating conditions and restrictions as given by the EGCS Technical Manual (ETM-A) as approved by the Administration.

4.2.1.2 Determination of the Certified Value should take into account the provisions of these Guidelines.

4.2.1.3 Each EGCS meeting the criterion of 4.2.1.1 should be issued an SECC by the Administration. The form of the SECC is given in appendix 1.

4.2.1.4 Application for an SECC should be made by the EGCS manufacturer, shipowner or other party.

4.2.1.5 Any subsequent EGCS of the same design and rating as that certified under 4.2.1.1 may be issued with an SECC by the Administration without the need for testing taking into account 4.2.1.1 subject to 4.1.3 of these Guidelines.

4.2.1.6 EGCSs of the same design, but with ratings different from that certified under 4.2.1.1 may be accepted by the Administration subject to 4.1.4 of these Guidelines.

4.2.1.7 EGCSs which treat only part of the exhaust gas flow of the uptake in which they are fitted should be subject to special consideration by the Administration to ensure that under all defined operating conditions the overall Emission Ratio value of the exhaust gas downstream of the system is no more than the Certified Value.

4.2.2 EGCS Technical Manual "Scheme A" (ETM-A)

4.2.2.1 Each EGCS should be supplied with an ETM-A provided by the manufacturer. This ETM-A should, as a minimum, contain the following information:

.1 the identification of the system (manufacturer, model/type, serial number and other details as necessary) including a description of the system and any required ancillary systems. In case a system contains more than one EGC unit, each EGC unit should be identified;

.2 the operating limits, or range of operating values, for which the unit is certified. These should, as a minimum, include:

.1 the maximum and, if applicable, minimum mass flow rate of exhaust gas;

.2 the maximum and, if applicable, minimum exhaust gas mass flow rate capacity of the EGC unit;

.3 the maximum fuel oil sulphur content the EGCS is certified for;

.4 the Certified Value;

.5 the power, type and other relevant parameters of the fuel oil combustion unit which the EGCS is to be connected to; for boilers also the maximum air/fuel ratio at 100% load should be given; and for diesel engines whether the engine is of 2 or 4-stroke cycle should be indicated;

.6 the maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2:1994);

.7 the exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGCS in operation;

.8 the maximum exhaust gas differential pressure across the EGC unit and the maximum exhaust gas inlet pressure;

.9 the salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and

.10 other factors concerning the design and operation of the EGCS relevant to achieving a maximum Emission Ratio value no higher than the Certified Value;

.3 any requirements or restrictions applicable to the EGCS or associated equipment necessary to enable the system to achieve a maximum Emission Ratio value no higher than the Certified Value;

.4 maintenance, service or adjustment requirements in order that the EGCS can continue to achieve a maximum Emission Ratio value no higher than the Certified Value. The maintenance, servicing and adjustments should be recorded in the EGCS Record Book;

.5 corrective actions to be applied if the following occurs or is expected to occur: operating conditions are outside approved ranges or limits; the discharge water quality criteria are not met; or exceedances of the Certified Value;

.6 a verification procedure to be used during surveys to ensure that the system's performance is maintained and that the system is used as required (see subsection 4.4);

.7 washwater and discharge water characteristics across the operating load range;

.8 design requirements for the treatment and monitoring of washwater and control of discharge water, including, for example, bleed-off water from closed-loop EGCS operation or discharge water temporarily stored within the EGCS; and

.9 detail the procedure to produce reports regarding operation in a non-compliant condition, or in a condition where the ongoing compliance would be temporary indicated in accordance with 8.2.8.

4.2.2.2 The ETM-A should be approved by the Administration.

4.2.2.3 The ETM-A should be retained on board the ship onto which the EGCS is installed and should be available for surveys as required.

4.2.2.4 Amendments to the ETM-A which reflect EGCS changes that affect performance with respect to emissions to air and/or water should be approved by the Administration. Where additions, deletions or amendments to the ETM-A are separate to the ETM-A as initially approved, they should be retained with the ETM-A and should be considered as part of it.

4.2.3 In-service surveys

4.2.3.1 The EGCS should be subject to survey on installation and at initial, annual/intermediate and renewals surveys by the Administration.

4.2.3.2 In accordance with regulation 10 of MARPOL Annex VI, the EGCS may also be subject to inspection by port State control.

4.2.3.3 Prior to use, each EGCS should be issued with an SECC by the Administration.

4.2.3.4 Following the installation survey given in 4.2.3.1, sections 2.3 and 2.6 of the Supplement to the ship's International Air Pollution Prevention Certificate should be duly completed.

4.3 Emission limits

4.3.1 Each EGCS should be capable of reducing emissions to equal to or less than the Certified Value at any load point, including fuel oil combustion unit idling, when operated in accordance with 4.2.2.1.2.

4.3.2 In order to demonstrate performance, emission measurements should be undertaken, with the agreement of the Administration, at a minimum of four load points. One load point should be at 95% to 100% of the maximum exhaust gas mass flow rate for which the unit is to be certified. One load point should be within ± 5% of the minimum exhaust gas mass flow rate for which the unit is to be certified. The other two load points should be equally spaced between the maximum and minimum exhaust gas mass flow rates. Where there are discontinuities in the operation of the system, the number of load points should be increased, with the agreement of the Administration, so that it is demonstrated that the required performance over the stated exhaust gas mass flow rate range is retained. Additional intermediate load points should be tested if there is evidence of an emission peak below the maximum exhaust gas mass flow rate and above, if applicable, the minimum exhaust gas flow rate. These additional tests should be of sufficient number as to establish the emission peak value.

4.4 Onboard verification procedures for demonstrating compliance

4.4.1 For each EGCS, the ETM-A should contain a verification procedure for use during surveys as required. This procedure should not require specialized equipment or an in-depth knowledge of the system. Where particular devices are required, they should be provided and maintained as part of the system. The EGCS should be designed in such a way as to facilitate inspection as required. The basis of the verification procedure is that if all relevant components and operating values or settings are within the approved ranges, then the performance of the EGCS can be assumed to meet the requirements without the need for actual continuous exhaust emission monitoring.

4.4.2 Included in the verification procedure should be all components and operating values or settings which may affect the operation of the EGCS and its ability to meet the Certified Value.

4.4.3 The verification procedure should be provided by the EGCS manufacturer and approved by the Administration.

4.4.4 The verification procedure should cover both a documentation check and a physical check of the EGCS.

4.4.5 The surveyor should verify that each EGCS is installed in accordance with the ETM-A and has an SECC as required.

4.4.6 At the discretion of the Administration, the surveyor should have the option of checking one or all of the identified components, operating values or settings. Where there is more than one EGC unit within the EGCS, the Administration may, at its discretion, abbreviate or reduce the extent of the survey on board; however, the entire survey should be completed for at least one of each type of EGC unit on board provided that it is expected that the other EGC units perform in the same manner.

4.4.7 The EGCS should include means to automatically record when the system is in use. These means should automatically record, at least at the frequency specified in 5.4.2, as a minimum, washwater pressure and flow rate at the EGC unit's inlet connection, exhaust gas pressure before and pressure drop across each EGC unit, fuel oil combustion unit load, and exhaust gas temperature before and after the EGC unit against the respective operating limits, or range of operating values. The data recording system should comply with the requirements of sections 7 and 8. In the case of a system consuming chemicals at a known rate as documented in ETM-A, recordings of such consumption in the EGCS Record Book also serves this purpose.

4.4.8 Under Scheme A, if a continuous exhaust gas monitoring system is not fitted, a daily spot check of the Emission Ratio for a duration of not less than five minutes at a minimum recording frequency of 0.1 Hz at normal working condition for each outlet to the atmosphere should be undertaken to verify compliance in conjunction with the continuous monitoring of the parameters stipulated in 4.4.7. The exhaust gas readings should be allowed to stabilize before commencing recording. Readings from the calibration procedure should be automatically recorded or noted in a calibration protocol. Emission values, which are used to determine the Emission Ratio, obtained after stabilization should be recorded. If a continuous exhaust gas monitoring system is fitted, only daily spot checks of the parameters listed in paragraph 4.4.7 would be needed to verify proper operation of the EGC unit.

4.4.9 An EGCS Record Book should be maintained on board the ship recording maintenance and service of the system including like-for-like replacement. This EGCS Record Book should be available during surveys as required and may be read in conjunction with engine-room logbooks and other data, as necessary, to confirm the correct operation of the EGCS. The form of this record should be provided by the EGCS manufacturer and approved by the Administration. Alternatively, this information may be recorded in the ship's planned maintenance record system as approved by the Administration. Alternatively, this information may be recorded in an Electronic Record Book as approved by the Administration. The EGCS Record Book entries should be maintained on board the ship for a minimum period of three years after the last entry has been made.

5 SCHEME B – EGCS APPROVAL, SURVEY AND CERTIFICATION USING CONTINUOUS MONITORING OF EMISSION RATIO

5.1 General

5.1.1 Scheme B provides for the approval of the means of continuous Emission Ratio monitoring, supported by daily parameter checks, which will subsequently be used at surveys, and otherwise as required, to demonstrate compliance with the objectives as given in the SECP.

5.2 Approval

5.2.1 The ETM-B, as defined in these Guidelines, should be approved by the Administration.

5.3 Survey and certification

5.3.1 The EGCS's exhaust gas monitoring system should be subject to survey on installation and at initial, annual/intermediate and renewals surveys by the Administration in order to demonstrate that it functions as given in the OMM. The scope of the installation or initial survey should include EGCS operation, as required, in order to demonstrate the functionality of the exhaust gas monitoring system.

5.3.2 Following the installation survey given in 5.3.1 and approval of documents as listed in 2.3.2, sections 2.3 and 2.6 of the Supplement to the ship's International Air Pollution Prevention Certificate should be duly completed.

5.4 Exhaust gas monitoring

5.4.1 The exhaust gas composition of the Emission Ratio should be measured at an appropriate position after the EGC unit and that measurement should be as given in section 6 as applicable. A suitable position could be downstream of the EGC unit, but before any possible mixing of outside ambient air or other additional air or gases with the exhaust gas.

5.4.2 SO_2(ppm) and CO_2(%) and, to not less than one decimal place, the Emission Ratio should be continuously monitored and recorded against the applicable Emission Ratio limit onto a data recording and processing device at a rate which should not be less than 0.0035 Hz whenever the EGCS is in operation. This monitoring may be suspended for service and maintenance periods of gas analyser and associated equipment as required by the OMM. Zero and span check calibration and instrument drift data should, as given in the OMM, be either recorded by the data recording system or manually entered in the EGCS Record Book as appropriate to the means used.

5.4.3 If more than one analyser is to be used to determine the Emission Ratio, these should have similar sampling and measurement times and the data outputs aligned to ensure that the Emission Ratio is fully representative of the exhaust gas composition.

5.5 Onboard verification procedures for demonstrating compliance with emission limits

5.5.1 The data recording system should be as given in sections 7 and 8. Data and the associated reports should be available to the Administration as necessary to demonstrate compliance as required and, in accordance with regulation 10 of MARPOL Annex VI, may also be subject to inspection by port State control.

5.5.2 Daily spot checks of the parameters listed in 4.4.7 are needed to verify proper operation of the EGCS and should be recorded in the EGCS Record Book or in the engine-room logger system.

5.6 EGCS Technical Manual "Scheme B" (ETM-B)

5.6.1 Each EGCS should be supplied with an ETM-B provided by the manufacturer. This ETM-B should, as a minimum, contain the following information:

.1 the identification of the system (manufacturer, model/type, serial number and other details as necessary) including a description of the system and any required ancillary systems. If a system consists of more than one EGC unit, each EGC unit should be identified;

.2 the operating limits, or range of operating values, for which the system is designed. These should, as a minimum, include:

.1 the maximum and, if applicable, minimum mass flow rate of exhaust gas;

.2 the advised maximum fuel sulphur content for the operational conditions the EGCS is designed for (Note: higher sulphur content fuel oils may be used provided the relevant Emission Ratio value is not exceeded);

.3 the power, type and other relevant parameters of the fuel oil combustion unit for which the EGCS is to be connected to. For boilers, the maximum air/fuel ratio at 100% load should also be given for diesel engines whether the engine is of 2 or 4-stroke cycle;

.4 the maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2:1994);

.5 the exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGCS in operation;

.6 the maximum exhaust gas differential pressure across the EGC unit and the maximum exhaust gas inlet pressure;

.7 the salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and

.8 other parameters as necessary concerning the operation of the EGCS;

.3 any requirements or restrictions applicable to the EGCS or associated equipment;

.4 corrective actions to be applied if the following occurs or is expected to occur: operating conditions are outside approved ranges or limits; the discharge water quality criteria are not met; or exceedances of the maximum allowable Emission Ratio;

.5 washwater and discharge water characteristics across the operating load range;

.6 design requirements for the treatment and monitoring of washwater and control of discharge water, including for example bleed-off water from closed-loop EGCS operation or discharge water temporarily stored within the EGCS; and

.7 detail the procedure for producing reports regarding operation in a non-compliant condition, or in a condition where the ongoing compliance would be temporary indicated in accordance with 8.2.8.

5.6.2 The ETM-B should be retained on board the ship onto which the EGCS is fitted. The ETM-B should be available for surveys as required.

5.6.3 Amendments to the ETM-B which reflect EGCS changes that affect performance with respect to emissions to air and/or water should be approved by the Administration. Where additions, deletions or amendments to the ETM-B are separate from the ETM-B as initially approved, they should be retained with the ETM-B and should be considered as part of it.

5.7 Onboard procedures for demonstrating compliance

5.7.1 An EGCS Record Book should be maintained on board the ship recording maintenance and servicing of the emission monitoring and ancillary components as given in the OMM including like-for-like replacements. The form of this record book should be approved by the Administration. This EGCS Record Book should be available at surveys as required and may be read in conjunction with engine-room logbooks and other data as necessary to confirm the correct operation of the EGCS. Alternatively, this information may be recorded in the ship's planned maintenance record system as approved by the Administration. Alternatively, this information may be recorded in an Electronic Record Book as approved by the Administration. The EGCS Record Book entries should be maintained on board the ship for a minimum period of three years after the last entry has been made.

6 EMISSION TESTING

6.1 Emission testing should follow the requirements of the NO_X Technical Code 2008 except as provided for in these Guidelines.

6.2 CO_2 should be measured using an analyser operating on the non-dispersive infrared (NDIR) principle and with additional equipment such as dryers as necessary. SO_2 should be measured using analysers operating on NDIR or non-dispersive ultra-violet (NDUV) principles and with additional equipment such as dryers as necessary. Other systems or analyser principles may be accepted, subject to the approval of the Administration, provided they yield equivalent or better results than those of the equipment referenced above. For acceptance of other CO_2 systems or analyser principles, the reference method should be in accordance with the requirements of appendix III of the NO_X Technical Code 2008.

6.3 The analysing equipment should be installed, operated, maintained, serviced and calibrated in accordance with the requirements as given in the OMM, at a frequency which ensures that the requirements of 1.7 to 1.10 of appendix III of the NO_X Technical Code 2008 are met at all times the equipment is in operation.

6.4 An exhaust gas sample for SO_2 should be obtained from a representative sampling point downstream of the EGC unit.

6.5 SO_2 and CO_2 should be monitored using either in situ or extractive sampling systems.

6.6 Extractive exhaust gas samples for SO_2 determination should be maintained at a sufficient temperature to avoid condensation of water in the sampling system and hence loss of SO_2.

6.7 If an extractive exhaust gas sample for determination needs to be dried prior to analysis it should be done in a manner that does not result in loss of SO_2 in the sample as analysed.

6.8 The SO_2 and CO_2 values should be compared on the basis of the same residual water content (e.g. dry or with the same wetness fraction).

6.9 In justified cases where the CO_2 concentration is reduced by the EGC unit, the CO_2 concentration can be measured at the EGC unit inlet, provided that the correctness of such a methodology can be clearly demonstrated. In such cases the SO_2 and CO_2 values should be compared on a dry basis. If measured on a wet basis the water content in the exhaust gas stream at those points should also be determined in order to correct the readings to dry basis values. For calculation of the CO_2 value on a dry basis, the dry/wet correction factor may be calculated in accordance with paragraph 5.12.3.2.2 of the NO_X Technical Code 2008.

6.10 Extractive sample systems should be verified to be free of ingress leakage in accordance with the analysing equipment manufacturers' recommendations at intervals as defined in the OMM. It should be verified that the system is free of ingress on initial start-up and as given in the OMM with the findings from those checks recorded in the EGCS Record Book.

6.11 The span gases for the SO_2 and CO_2 analyser should be a mixture of SO_2 and/or CO_2 and nitrogen at a concentration of more than 80% of the full scale of the measuring range used. The span gas for the CO_2 should conform to the requirements of section 2 of appendix IV of the NO_X Technical Code 2008. Other equivalent arrangements, as detailed in the OMM, may be accepted by the Administration.

7 DATA RECORDING AND PROCESSING DEVICE

7.1 The recording and processing device should be of robust, tamper-proof design with read-only capability.

7.2 The recording and processing device should record, whenever the EGCS is in operation, the data described in 4.4.7, 5.4.2, and 10.3 as applicable, including overboard discharges from any associated tanks within the system, against UTC and ship's position as given by a Global Navigational Satellite System (GNSS) and whether the ship was inside or outside an Emission Control Area as given by regulation 14.3 at that time. The device should also be capable of:

.1 (Scheme B only) being automatically set, or pre-set, with the Emission Ratio limit value as appropriate to the sea area, in relation to regulation 14.3, where the ship is operating;

.2 being automatically set, or pre-set, with the applicable overboard pH limit value;

.3 being automatically set with the applicable PAH limit value;

.4 recording the aggregated time in excess of 15 minutes over any rolling 12-hour period that the differential PAH value is above the set limit value by more than 100%;

.5 being pre-set with the applicable turbidity limit value;

.6 recording the aggregated time in excess of 15 minutes over any rolling 12-hour period that the rolling average differential turbidity value is above the set limit value by more than 20%; and

.7 recording preset and set limit values.

7.3 The recording and processing device should be capable of preparing reports over specified time periods.

7.4 Data should be retained for a period of not less than 18 months from the date of recording. If the device is changed over that period, it should be ensured that the required data is retained on board and available as required for inspection.

7.5 The device should be capable of downloading a copy of the recorded data and reports in a readily useable format clearly indicating periods of non-compliance. Such copy of the data and reports should be available to the Administration or port State control as requested.

8 ONBOARD MONITORING MANUAL (OMM)

8.1 An OMM should be prepared to cover each EGCS installed in conjunction with a fuel oil combustion unit, which should be identified, for which compliance is to be demonstrated.

8.2 The OMM should, as a minimum, include:

.1 for extractive exhaust gas sampling systems, the position from which the gas sample is drawn together with details, arrangement and operating ranges of the analysers and all necessary ancillary components or requirements including, but not limited to, sample probe assembly, sample transfer line and sample treatment unit;

.2 for in situ exhaust gas analysers, the location and arrangement of the analyser in the exhaust duct, operating ranges and all necessary ancillary components or requirements;

.3 for inlet water and discharge water monitoring, the positions from which the water samples are drawn, the location and arrangement of the analysers together with details of any necessary ancillary services such as sample transfer lines and sample treatment units;

.4 the analysers to be used for monitoring of exhaust gas, inlet water, discharge water, their service, maintenance, and calibration requirements. Templates covering the minimum information which should be included are provided in appendix 5;

.5 the zero and span check procedures of the exhaust gas analysers and calibration of washwater, discharge water and inlet water analysers together with reference materials to be used and the required frequency of those checks;

.6 the operating parameter instruments to be used described in 4.4.7 or 5.5.2;

.7 the installation, operation, adjustment, maintenance, servicing and calibration requirements and procedures of the analysers, associated ancillary equipment and operating parameter measurement instruments;

.8 the means by which ongoing compliance would be temporarily indicated in the case of the failure of a single monitoring device, taking into account that transitory periods of emission exceedances and/or isolated spikes in the recorded output in the Emissions Ratio do not necessarily mean non-compliant exceedance of emissions and should therefore not be considered as a breach of the requirements;

.9 the data recording system and how it is to be operated, data retained and the types of reports which it can produce;

.10 guidance as to data or other indications which may signify a malfunction of either an analyser, an item of ancillary equipment or an operating parameter sensor together with the fault-finding and corrective actions which should be taken;

.11 other information or data relevant to the correct functioning or use of the monitoring system or its use in demonstrating compliance; and

.12 where the information described in .1 to .11 above is referring to detailed descriptions of procedures, reference can be made to additional documents (e.g. manufacturer's documentation) which should be considered part of the OMM.

8.3 The OMM should specify how the EGCS, operating parameter measurement instruments and the exhaust gas and discharge water monitoring systems are to be surveyed in order to verify that:

.1 the EGCS conforms to the ETM-A or ETM-B as applicable;

.2 the operating parameter instruments installed and used on board are as approved per the OMM;

.3 the exhaust gas and discharge water monitoring systems used on board are as approved per the OMM;

.4 inspection, maintenance, servicing, calibration and adjustments have been undertaken as required and those actions recorded in the EGCS Record Book as required; and

.5 the operating parameter instruments and the exhaust gas and discharge water monitoring systems are correctly functioning.

8.4 Under scheme B, where operation of the EGCS is required in order to demonstrate the functionality of the monitoring system during installation or initial surveys, the OMM should describe the operational condition(s) which demonstrate the operational behaviour of the monitoring system and which should be used when surveying in accordance with paragraph 5.3.1. The description of operational condition(s) may include:

.1 the connected fuel oil combustion unit load point(s); and

.2 the minimum operating time at a given load point.

8.5 The OMM should be:

.1 approved by the Administration; and

.2 retained on board the ship onto which the EGCS is installed and should be available for surveys as required.

9 SHIP COMPLIANCE

9.1 SO_X Emissions Compliance Plan (SECP)

9.1.1 For a ship which is to use an EGCS, in part or in total, as an approved equivalent means to the requirements given by regulation 14.1 or 14.4 of MARPOL Annex VI there should be an SECP for the ship, approved by the Administration.

9.1.2 The SECP should list each fuel oil combustion unit which may use fuel oil supplied in accordance with the requirements of regulations 14.1 and/or 14.4 of MARPOL Annex VI.

9.1.3 The SECP should list each fuel oil combustion unit which may use Scheme A and/or B of these Guidelines together with identification of the EGCS to which it is connected and whether this control may be applied continuously or only inside or only outside the Emission Control Areas given by regulation 14.3 of MARPOL Annex VI.

9.1.4 The SECP should advise that records should be kept of actions initiated to meet the requirement of these Guidelines in case of breakdown of the EGCS or associated equipment, and that the relevant flag and port State's Administration should be notified, in accordance with MEPC.1/Circ.883/Rev.1.

9.2 Demonstration of compliance

9.2.1 Scheme A

9.2.1.1 The SECP should refer to, not reproduce, the ETM-A, EGCS Record Book or engine-room logger system and OMM as specified under Scheme A.

9.2.1.2 For all fuel oil combustion units listed under 9.1.3, details should be provided demonstrating that the rating and restrictions for the EGCS as approved, under 4.2.2.1.2, are complied with.

9.2.1.3 Required parameters should be monitored and recorded as described in 4.4.7 when the EGCS is in operation in order to demonstrate compliance.

9.2.2 Scheme B

9.2.2.1 The SECP should refer to, not reproduce, the ETM-B, EGCS Record Book or engine-room logger system and OMM as specified under Scheme B.

10 DISCHARGE WATER

10.1 Discharge water quality criteria[1]

10.1.1 EGCS discharge water should comply with the following criteria prior to being discharged into the sea:

10.1.2 pH criteria

10.1.2.1 The discharge water pH should comply with one of the following requirements, which should be recorded in the ETM-A or ETM-B as applicable:

.1 The discharge water should have a pH no lower than 6.5 measured at the ship's overboard discharge with the exception that, during manoeuvring and transit, a maximum difference of 2 pH units is allowed between the inlet water and overboard discharge values.

.2 The pH discharge limit, at the overboard monitoring position, is the value that will ensure a pH no lower than 6.5 at a distance of 4 m from the overboard discharge point with the ship stationary, and is to be recorded as the overboard pH discharge limit in the ETM-A or ETM-B. The overboard pH discharge limit can be determined either by means of direct measurement, or by using a calculation-based methodology (computational fluid dynamics or other equally scientifically established empirical formulae) as agreed by the Administration, and in accordance with the following conditions to be recorded in the ETM-A or ETM-B:

[1] The discharge water quality criteria should be reviewed in the future as more data become available, including relevant research and development results, on the content of discharge water and its effects, taking into consideration any advice given by GESAMP. Guidance for voluntary discharge water data collection is included in appendix 3.

.1 all EGC units connected to the same outlets are operating at their full loads (or highest practicable load) and with fuel oil of the maximum sulphur content for which the units are to be certified (Scheme A) or used with (Scheme B);

.2 if a test fuel with lower sulphur content, and/or test load lower than maximum, sufficient for demonstrating the behaviour of the discharge water plume is used, the plume's mixing ratio must be established based on the titration curve of seawater. The mixing ratio would be used to demonstrate the behaviour of the discharge water plume and that the overboard pH discharge limit has been met if the EGCS is operated at the highest fuel sulphur content and load for which the EGCS is certified (Scheme A) or used with (Scheme B);

.3 where the discharge water flow rate is varied in accordance with the EGCS gas flow rate, the implications of this for the part load performance should also be evaluated to ensure that the overboard pH discharge limit is met under any load;

.4 reference should be made to a seawater alkalinity of 2.2 mmol/L and pH 8.2;[2] an amended titration curve should be applied where the testing conditions differ from the reference seawater, as agreed by the Administration (example titration curve for reference seawater conditions is presented in appendix 4); and

.5 if a calculation-based methodology is to be used, details should be submitted to allow its verification such as but not limited to supporting scientific formulae, discharge point specification, discharge water flow rates, designated pH values at both the discharge and 4 m location, titration and dilution data.

10.1.3 PAHs (Polycyclic Aromatic Hydrocarbons)

10.1.3.1 The discharge water PAH should meet the criteria below. The appropriate limit should be specified in the ETM-A or ETM-B.

10.1.3.2 The maximum continuous PAH concentration in the discharge water should not be greater than 50 μg/L PAH_{phe} (phenanthrene equivalent) above the inlet water PAH concentration. For the purposes of this criterion, the PAH concentration in the discharge water should be measured downstream of the water treatment equipment including any reactant dosing unit, if used, but upstream of any dilution for control of pH, if used, prior to discharge.

10.1.3.3 The 50 μg/L limit described above is normalized for a discharge flow rate, before any dilution for pH control, of 45 t/MWh where the MW refers to the aggregated MCR of all those fuel oil combustion units whose EGCS discharge water PAH is being monitored at that point. In cases where sensors are installed in a separate measurement cell, the PAH limit applies to the flow in the main discharge pipe from which the water is bypassed. This limit would have to be adjusted upward for lower washwater flow rates (t/h) per MW, and vice versa, according to the table below.

[2] These values could be revised within two years for new installations following the adoption of these amended Guidelines upon further inputs on the physical state of the seas resulting from the use of exhaust gas cleaning systems.

Table 5: Criteria for discharge water PAH concentration

Specific Discharge Water flow rate (before dilution for pH control) **(t/MWh)**	**Discharge concentration limit (μg/L PAH_{phe} equivalents)**	**Measurement technology**
0-1	2250	Ultraviolet light*
2.5	900	– " –*
5	450	Fluorescence[3]
11.25	200	– " –
22.5	100	– " –
45	50	– " –
90	25	– " –

*Alternative measurement technologies may be used with the agreement of the Administration.

10.1.3.4 For an aggregated 15-minute period in any rolling 12-hour period, the continuous PAH_{phe} concentration limit may exceed the limit described above by up to 100%. This would allow for an abnormal start-up of the EGC unit.

10.1.4 Turbidity/Suspended particulate matter

10.1.4.1 The discharge water treatment system should be designed to minimize suspended particulate matter, including heavy metals and ash. The turbidity of the discharge water, following treatment equipment, including any reactant dosing, but upstream of any other dilution unit, if used, should meet the criteria below. The limit should be recorded in the ETM-A or ETM-B.

10.1.4.2 The maximum continuous turbidity in the discharge water should not be greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, above the inlet water turbidity. However, during periods of high inlet turbidity, the precision of the measurement device and the time lapse between inlet measurement and outlet measurement are such that the use of a difference limit is unreliable. Therefore, all turbidity difference readings should be a rolling average over a maximum 15-minute period to a maximum of 25 FNU or NTU.

10.1.4.3 For an aggregated 15-minute period in any rolling 12-hour period, the continuous turbidity discharge limit may be exceeded by 20%.

10.1.5 Nitrates

10.1.5.1 The discharge water treatment system should prevent the discharge of nitrates beyond that associated with a 12% removal of NO_X from the exhaust, or beyond 60 mg/l normalized for discharge water flow rate of 45 t/MWh, whichever is the greater, where the MW refers to the MCR or 80% of the power rating of the fuel oil combustion unit.

10.1.5.2 Within the first three months of operation after installation/initial survey and three months prior to each renewal survey a sample of the discharge water from each EGCS should be drawn and analysed for nitrate content and results should be made available

[3] For any flow rate > 2.5 t/MWh fluorescence technology should be used.

to the Administration. However, the Administration may require an additional sample to be drawn and analysed at its discretion. The nitrate discharge data and analysis certificate is to be retained on board the ship as part of the EGCS Record Book and to be available for inspection as required by port State control or other parties. Criteria in respect of sampling, storage, handling and analysis should be detailed in the ETM-A or ETM-B as applicable. To assure comparable nitrate discharge rate assessment, the sampling procedures should take into account 10.1.5.1, which specifies the need for discharge water flow normalization. Nitrates discharge data is to be presented as the difference between concentrations in the inlet water and in the discharge water. The test method for nitrate should be ISO 13395:1996, ISO 10304-1:2007, US EPA 353.2 or other internationally accepted equivalent test standard (suitable for seawater).

10.1.5.3 Data on discharge water nitrate concentrations gathered from EGCSs of similar design could be used as an alternative to the sampling, analysis and quantification requirements of 10.1.5.2 with the agreement of the Administration based on an engineering analysis which demonstrates the design similarities in respect of nitrate concentrations in the discharge water.

10.1.6 Washwater and discharge water additives and other substances

10.1.6.1 Additional assessment of the discharge water may be required for those EGCS technologies which make use of chemicals, additives, preparations or create relevant chemicals in situ. The assessment may take into account relevant guidelines, such as the *Procedure for approval of ballast water management systems that make use of active substances (G9)* (resolution MEPC.169(57)), to determine if additional discharge water quality criteria are appropriate. If only the following chemicals are used and the discharge water pH does not exceed 8.0, no additional assessment is needed:

.1 neutralization agent (caustic substance), such as sodium hydroxide (NaOH) or sodium carbonate (Na_2CO_3); and

.2 flocculants, which are used for approved marine oily-water separating equipment.

10.1.7 Discharge water from temporary storage

10.1.7.1 Any discharge water originating from the EGCS and discharged overboard following temporary storage within any tank designed for that purpose and featured in the ETM-A or ETM-B should be monitored/recorded in accordance with 10.2.1, and meet, independent of any flow rate, the following discharge water criteria:

pH	See paragraph 10.1.2
PAH	Maximum of 50 µg/L PAH_{phe} (phenanthrene equivalence) before any dilution for control of pH
Turbidity	Not greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, before any dilution for pH control

10.1.7.2 When demonstration of compliance with the provisions contained within this section is not possible, the water intended for discharge should be considered EGCS residue.

10.2 Discharge water monitoring

10.2.1 When the EGCS is operated in ports, harbours or estuaries, or during any discharges from temporary storage, the discharge water monitoring and recording should be continuous. The values monitored and recorded should include pH, PAH, turbidity and temperature. In other areas the continuous monitoring and recording equipment should also be in operation, whenever the EGCS is in operation, except for short periods of maintenance, and cleaning of the monitoring equipment as defined in the OMM. Whenever there are overboard discharges of discharge water from temporary onboard storage, no maintenance or cleaning of the monitoring equipment should take place. Those EGCS which apply degassing of the sampled discharge water for the purpose of turbidity monitoring should ensure that particles do not settle during degassing, as this would underestimate the real turbidity value.

10.2.2 The permissible deviations of the discharge water monitoring equipment should not exceed the following:

pH	0.2 pH units
PAH	5% of nominal standard test concentration used. That nominal concentration value should be not less than 80% of the scale range used
Turbidity	2 FNU or NTU

Calibration intervals should be such that the above performance requirements are met. Calibration and calibration checks should be done according to the manufacturer's specification.

10.2.3 The pH electrode and pH meter should have a resolution of 0.1 pH units and temperature compensation. The electrode performance and accuracy should at least comply with the requirements defined in BS 2586 or ASTM D1293-18 and the meter should meet or exceed IEC 60746-2:2003 or other internationally accepted equivalent standards. pH electrodes or pH meters which comply with another accepted standard or technical specification which is in force are deemed to be the equivalent of the equipment, provided these standards or technical specifications conform to standards BS 2586 or ASTM D1293-18 or IEC 60746-2:2003, and ensure at least a like-for-like level of requirements.

10.2.4 The PAH monitoring equipment should be capable of monitoring PAH in water in a range to at least twice the discharge concentration limit given in the table above. The equipment should be demonstrated to operate correctly and not deviate more than 5% in discharge water with turbidity within the working range of the application.

10.2.5 For those applications discharging at lower flow rates and higher PAH concentrations, ultraviolet light monitoring technology or equivalent should be used due to its reliable operating range.

10.2.6 The turbidity monitoring equipment should meet requirements defined in ISO 7027. The turbidimeter should identify when the turbidity is unable to be reliably quantified.

10.3 Approval of the discharge water monitoring systems

10.3.1 The discharge water monitoring system should be approved by the Administration.

10.4 Water monitoring data recording

10.4.1 The data recording system should comply with the requirements of sections 7 and 8 and should continuously record pH, PAH and turbidity in accordance with 10.2.1 at a frequency of not less than 0.0111 Hz.

10.4.2 Calibration and instrument drift data should, as given in the OMM, be either recorded by the data recording system or manually entered in the EGCS Record Book as appropriate to the means used.

10.5 EGCS Residues

10.5.1 Residues generated by the EGCS should be delivered ashore to adequate reception facilities. Such residues should not be discharged to the sea or incinerated on board.

10.5.2 Each ship fitted with an EGCS should record the storage and disposal of EGCS residues in the EGCS Record Book, including the date, time and location of such storage and disposal.

10.6 Maintenance and servicing records

10.6.1 The EGCS Record Book as required by either 4.4.9 or 5.7.1 should also be used to record maintenance and servicing of the washwater and discharge water monitoring systems and ancillary components as given in the OMM including like-for-like replacement.

10.7 Design guidance for water sampling points/valves

10.7.1 Each sampling point should be installed at a location that is representative of the main washwater or discharge water stream and accessible to personnel. The sampling extraction point should be open in the direction of the water flow.

APPENDIX 1

FORM OF SO_X EMISSION COMPLIANCE CERTIFICATE

Badge
or
Cipher

NAME OF ADMINISTRATION

SO_X EMISSION COMPLIANCE CERTIFICATE

CERTIFICATE OF APPROVAL FOR EXHAUST GAS CLEANING SYSTEMS

Issued under the provisions of the Protocol of 1997, as amended, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto under the authority of the Government of:

....
(full designation of the country)

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

This is to certify that the exhaust gas cleaning system (EGCS) listed below has been surveyed in accordance with the specifications contained under Scheme A in the *20XX Guidelines for exhaust gas cleaning systems* adopted by resolution MEPC.YYY(ZZ).

This Certificate is valid only for the EGCS referred to below:

System manufacturer	**Model/ type**	**Serial number**	**This EGCS is certified as providing following equivalency:**		**EGCS – Technical Manual for Scheme A (ETM-A) approval reference**
			Fuel oil sulphur limit values:	**Maximum sulphur content of fuel oils to be used:**	
			0.10%	**_____% / n/a***	
			0.50%	**_____%**	

* delete as applicable

A copy of this Certificate should be carried on board the ship fitted with this EGCS at all times.

This Certificate is valid for the life of the EGCS, subject to surveys in accordance with subsection 4.2 of the Guidelines and regulation 5 of MARPOL Annex VI, installed in ships under the authority of this Government.

Issued at ....

(place of issue of certificate)

Date dd/mm/yyyy

....	....
(date of issue)	(*signature of duly authorized official issuing the certificate)*

(Seal or Stamp of the authority, as appropriate)

APPENDIX 2

EMISSION RATIO

1 This appendix is included to explain the background to the use of the Emission Ratio, defined in 2.3 of these Guidelines, as the criterion for the demonstration of equivalency with the fuel oil sulphur limits given in regulation 14 of MARPOL Annex VI. In addition, the basis of the Emission Ratio limit values as given in 1.3 of these Guidelines is also explained.

2 The carbon content of any fuel oil used for power generation by combustion exits that system essentially in the form of carbon dioxide (CO_2). While certain amounts of the inflow carbon may form deposits within that system, be incorporated into any direct contact lubricant or exit in the exhaust gas as carbon monoxide or gaseous or particulate hydrocarbons, overall these quantities are not significant in comparison to the flow of CO_2. This applies equally to all combustion systems: internal combustion engines, boilers and gas turbines.

3 Similarly, the sulphur content of a fuel oil used for combustion will exit that system essentially as sulphur dioxide (SO_2) in the hot exhaust gas stream. Again, although a certain amount may be retained as sulphur compounds within the system or as other sulphur compounds in the exhaust gas stream, these are not significant in comparison to the flow of SO_2.

4 Hence, although the CO_2 concentration in the exhaust gas will vary in accordance with the excess air ratio applied, the ratio of CO_2 to SO_2 concentrations will be fixed by the carbon/sulphur ratio of the fuel oil used. In those instances where an exhaust gas cleaning system (EGCS) covered by these Guidelines is fitted, the effect will be to reduce the SO_2, but not the CO_2 content of the exhaust gas. Consequently, the SO_2/CO_2 ratio after the system will reflect the effectiveness of that system in removing SO_2 from the exhaust gas.[1] The post-EGCS SO_2/CO_2 ratio, the Emission Ratio, will largely correspond to that which would otherwise have been obtained if a lower sulphur fuel oil had been used but without the EGCS.

5 The principal elements present in petroleum-derived liquid fuel oils are carbon, hydrogen and sulphur and in some instances also nitrogen and oxygen. The actual proportions differ in each case. In order to derive the Emission Ratios corresponding to different fuel oil sulphur limit values, the fuel oil compositions given in 6.4.11.1.2 (table 9) of the NO_X Technical Code 2008 are taken as the starting points in table 1 below. The given compositions for both distillate and residual fuel oils omit sulphur content, but these are simply the difference between the summation of the given values and 100% and hence are 0.20% for the distillate example and 2.60% for the residual. In order to estimate the carbon and hydrogen proportions of fuel oils with other sulphur content values the carbon/hydrogen ratio and the "nitrogen+oxygen" content are assumed to be unchanged for the respective fuel oils. In table 1 the carbon contents are calculated for fuel oil having a sulphur content for both the distillate and the residual fuel oil of 1.50% as has been used in earlier versions of these Guidelines.

6 From the derived carbon contents and selected sulphur content value the molar ratio of fuel sulphur to fuel carbon is obtained in table 2 and from those the corresponding ratios of SO_2 and CO_2. One of the particular features of petroleum-derived liquid fuel oils is that despite the wide range of physical properties, such as viscosity and density, between distillates and residuals there is only a very limited range in terms of carbon composition. Hence it is a reasonable proposition to use a single SO_2/CO_2 ratio in order to represent all such fuel oils; in this instance 65 has been taken to correspond to the Emission Ratio which would be obtained if using a fuel oil of 1.50% sulphur content.[2] The value of 1.50% sulphur content was used as the basis of these calculations as that was the original limit value for Emission Control Areas as given by the MARPOL Annex VI text as adopted in 1997, and which has been subsequently amended.

7 From the Emission Ratio corresponding to 1.50% sulphur the Emission Ratios corresponding to the various sulphur limits now given in regulation 14 of MARPOL Annex VI are obtained (see table 3).

Table 1: Fuel oil carbon content values

Distillate fuel oil – petroleum-derived

Carbon	Given	% m/m	86.2	
	Calculated	% m/m		85.08
Hydrogen	Given	% m/m	13.6	
	Calculated	% m/m		13.42
Sulphur		% m/m	0.2	1.50
Nitrogen + Oxygen		% m/m	0	0
Carbon / Hydrogen ratio			6.338	6.338

Residual fuel oil – petroleum-derived

Carbon	Given	% m/m	86.1	
	Calculated	% m/m		87.08
Hydrogen	Given	% m/m	10.9	
	Calculated	% m/m		11.02
Sulphur		% m/m	2.60	1.50
Nitrogen + Oxygen		% m/m	0.40	0.40
Carbon / Hydrogen ratio			7.899	7.899

Table 2: Emission Ratio values for 1.50% sulphur fuel oil

			Distillate	Residual
Fuel	Carbon	% m/m	85.08	87.08
	Sulphur	% m/m	1.50	1.50
	Carbon	mol/kg	70.90	72.57
	Sulphur	mol/kg	0.469	0.469
	S/C ratio	mol/mol	0.00661	0.00646
Exhaust gas Emission Ratio		SO_2 ppm / CO_2 %	66.12	64.60
			65	

Table 3: Emission Ratios corresponding to fuel oil sulphur content[2]

Fuel oil sulphur content % m/m	Emission Ratio
1.50	65
0.50	21.7
0.10	4.3

Note 1. Should treatment systems be developed that also reduce the CO_2 content, the core principle still applies except that in order to assess effectiveness in terms of SO_2 reduction the CO_2 value used would be that prior to that reduction i.e. CO_2 being measured at a point upstream of that treatment device.

Note 2. The given Emission Ratios only apply where a petroleum-derived liquid fuel oil is being used. For other fuel oils specific Emission Ratio values would need to be determined, and approved by the Administration, based on the particular composition of the fuel oil in question.

APPENDIX 3

DISCHARGE WATER DATA COLLECTION

1 Introduction

1.1 The discharge water quality criteria are intended to act as initial guidance for implementing EGCS designs. The criteria should be reviewed in the future as more data become available on the contents of the discharge and its effects, taking into account any advice given by GESAMP.

1.2 Administrations should therefore invite the collection of relevant data. To this end, shipowners in conjunction with the EGCS manufacturer are invited to sample and analyse samples of EGCSs, taking into account section 2 and section 3 of this appendix, as appropriate.

1.3 The sampling could be conducted during approval testing or shortly after commissioning and at about 12-monthly intervals.

2 Recommended procedure for sampling

2.1 In order to evaluate the contents of the discharge water and its effects, it is recommended that samples be analysed for the parameters listed under paragraph 2.4.1 of this appendix.

2.1 Preparation

2.1.1 This section describes preparations recommended prior to any sampling.

2.1.2 The EGCS should be equipped with sampling points for sampling of the following water streams:

.1 inlet water (for background);

.2 water after the EGC unit after treatment (if applicable) but before any kind of dilution; and

.3 discharge water after treatment and dilution.

2.1.3 Preparation for sampling, handling and transport

2.1.3.1 Sampling equipment

The sampling equipment and pre-prepared sample containers should be made ready prior to sampling. The equipment can be ordered from the laboratory performing the analysis. The equipment should be ordered well before the sampling takes place, taking into consideration the itinerary of the ship.

The table below lists the recommended physical properties of the sampling bottles needed. It takes ISO 5667-3 and the appropriate analytical standard into account, but other equivalent standards can also be used. The table furthermore informs how the samples should be stored when drawn and when at the latest they need to reach the laboratory for analysis.

Parameter	Bottle material	Volume	Method specifying sampling bottle requirements	Preservative	Storage temperature	Maximum time until analysis
NO_2^-/NO_3^-	PE	250 mL	ISO 10304-1	No preservative	Frozen (≤ -18°C)	8 days
Total Metals	PE	500 mL	ISO 17294-2	HNO_3 Acid	Cooled (4°C) / dark	1 month
Dissolved Metals	PE	500 mL	ISO 17294-2	No preservative	Cooled (4°C) / dark	1 month
PAHs	Amber-glass with PTFE seal	2 L (OL), 1 L (CL)	DIN EN 16691 or EPA 8270	No preservative	Cooled (4°C) / dark	7 days
Hydrocarbon oil index (GC-FID analysis)	Glass	1L	ISO 9377-2	Mineral acid pH<2	Cooled (4°C) / dark	4 days

It is practical to label sampling bottles before sampling. Identify each bottle such that it can be tracked back to sampling point, sampling parameter, EGCS operation mode and EGCS load.

2.1.3.2 Preparation for storage and holding of samples

To ensure proper storage and holding, crew need to appoint an appropriate space on board for samples and ice packs, preferably in an enclosed container in a cool space without direct sunlight.

2.1.3.3 Preparation for transport

If samples need to be transported with ice packs, the ice packs should be deep-frozen at least 48 h prior to sampling.

It is recommended to arrange shipping of the samples in advance with the port agent of the destination port.

2.1.3.4 Preparation of personnel conducting the sampling

To ensure the health and safety of the personnel, it is recommended to wear the following equipment:

2.1.3.4.1 Protective eyeglasses/goggles, ear protection, gloves, protective clothing and safety shoes

2.1.3.5 Personnel qualifications and responsibilities.

It is important that the personnel taking the samples are well trained. They should be aware of:

.1 how the system is working and where the sampling points are located; and

.2 how to dispose of the flushing water collected during flushing.

The personnel should be competent in drawing samples and should know the location of the sampling points and how to safely dispose of the collected flushing water.

2.1.3.6 Information prior to sampling

It is recommended to complete the templates under 3.1 prior to sampling.

2.2 Collection

2.2.1 Sample time schedule

It is recommended to prepare a sampling time plan in advance in agreement with the crew, considering when at the latest the samples need to be analysed at laboratory. The sampling plan should contain information that can identify which bottle contains which water (OL/CL, inlet/outlet, etc.) and at which hour the sample was drawn. In this manner, continuous recorded EGCS control parameters can be retrieved at a later stage. Sampling should be undertaken with the EGCS operating above 50% of maximum exhaust gas flow (4.2.2.1.2.1 / 5.6.1.2.1).

2.2.2 Filling the sampling bottle

To prevent contamination during sampling, the following practices are recommended:

.1 use sampling bottles prepared by the laboratory;

.2 the water flow and thus the engine load(s) should be steady before and during sampling;

.3 the sampling valve should be flushed with a minimum of 10 litres of sampling water before samples are taken and it should not be closed or touched after flushing or before the sampling is done;

.4 if more than one bottle is filled, the sampling valve should not be closed in between;

.5 the use of any hydrocarbon-based cleaning agents at the sampling point should be avoided; and

.6 fill the sampling bottles to the brim and close firmly to avoid air in the bottles.

2.2.3 Information while sampling

It is recommended to complete the template under 3.2 while sampling.

2.3 Transportation

Sampling equipment to be used during transportation should meet provisions under 2.1.3.1 above.

2.3.1 Transportation container

For transportation an insulated and leak-proof container should be used. The transportation container should be provided by the laboratory. It should be able to hold a sufficient quantity of ice packs.

2.3.2 Shipping to the laboratory

Samples should be shipped to the laboratory as fast as possible. The transportation container should be labelled in accordance with local requirements for shipping and handling of water samples.

Immediately before handing over the samples to the port agent, the ice packs should be put into the box.

2.3.3 Chain of custody

A formal chain of custody process is required, with records.

Usually it is not necessary to include a customs declaration as these are water samples of zero commercial value.

2.3.4 Information from the laboratory

Take into consideration any information provided by the laboratory.

2.4 Sample preparation and analysis

Analysis should be undertaken by ISO 17025-accredited laboratories using EPA, ISO or equivalent test procedures. Methods used in the laboratories need to be within the scope of ISO 17025 accreditation of the laboratory.

2.4.1 To ensure comparability of laboratory results, the following methods are recommended:

Parameter	Recommended method for sample analysis	Recommended method for sample preparation
Polycyclic Aromatic Hydrocarbons (PAH): 16 EPA PAHs: Acenaphthene Acenaphthylene Anthracene Benzo-a-anthracene Benzo-a-pyrene Benzo-b-fluoranthene Benzo-g,h,i-perylene Benzo-k-fluoranthene Chrysene Dibenzo-a,h-anthracene Fluoranthene Fluorene Indeno-1,2,3-pyrene Naphthalene Phenanthrene Pyrene Sum of 16 PAHs	EN 16691:2015 or ISO 28540:2011 (recognizing EN 16691 as ISO is currently under consideration) or EPA 8270	* * EPA 3510; or EPA 3511; or EPA 3520.
Oil detailed GC FID analysis	ISO 9377-2:2000	*

Determination of Hydrocarbons Oil Index		
Nitrate and nitrite (NO_3^-/NO_2^-)	ISO 10304-1:2007 or ISO 15923-1:2013 or ISO 13395:1996 or EPA 353.2	* * * *
Total Metals: - Cd - Cu - Ni - Pb - Zn - As - Cr - V - Se	ISO 17294-2:2016 or EPA 200.8 or EPA 200.9	ISO 15587-1:2002 * *
Dissolved Metals: - Cd - Cu - Ni - Pb - Zn - As - Cr - V - Se	ISO 17294-2:2016 or EPA 200.8 or EPA 200.9	ISO 17294-2:2016 and filtration on 0.45 µm + HNO_3 EPA 200.8 and filtration on 0.45 µm + HNO_3 EPA 200.9 and filtration on 0.45 µm + HNO_3
Discharge water pH should be determined by instant onboard measurements	Record pH immediately on board	Record pH immediately on board

* Preparation method is included in the analytical method.

3 Recommended template for submitting sampling data

When submitting sampling data to the Administration, the data should include information according to paragraphs 1 and 2 as well as the results from the analyses as described under paragraph 2.4.

When submitting sampling data to the Administration, the following template is recommended.

3.1 Data Template Part 1 Information prior to sampling		
Parameter	Value	Unit
3.1.1 Ship information		
Ship's name		
IMO number		
Ship build date		dd.mm.yyyy
3.1.2 Combustion unit(s) details Engine questions should be answered for every fuel-burning facility connected to the EGCS		

Number of combustion units connected to EGCS		
Combustion unit(s) manufacturer(s)		
Type of combustion unit(s) (ME, AE, 2/4-stroke, boiler)		
EGCS capacity in MW		
3.1.3 EGCS general		
Name of manufacturer		
Name of system		
Number of streams	single/multiple	
System operation mode	open/closed/hybrid	
Type of washwater treatment		
EGCS retrofit or new building		
Installation date		
ETM scheme A or B approval		
Additional notes:		

3.2 Information in conjunction with sampling for each operation mode (OL and/or CL)		
Parameter	Value	Unit
3.2.1 Ship information during sampling		
Cruise speed		knots
Start of sampling date and time		UTC
Stop of sampling date and time		UTC
Ship's position start of sampling		GPS
Ship's position end of sampling		GPS
Weather conditions (during sampling)		calm/rough
3.2.2 EGCS operation		
Approx. EGCS load		%
System operation mode	open/closed	
Type of washwater treatment, if any		
Added chemicals for treatment		Name
Dosage rate of added chemicals for treatment during sampling		l/m^3
Average washwater flow rate to EGCS during sampling period		m^3/h
Average dilution water flow rate during sampling period, if given or relevant		m^3/h
3.2.3 Combustion unit(s) operation		
Approx. total combustion unit(s) load to EGCS		MW
Total fuel consumption		t/h
Fuel sulphur content (according BDN)		
Fuel viscosity if available		
Additional notes:		

3.2.4 Online monitoring readings during sampling, for each sampling point			
Monitoring unit	pH	PAH_{phe} µg/L or ppb	Turbidity FNU or NTU
Inlet (if available), average during sampling period			
Discharge point, average during sampling period (outlet)		NA	NA
Before dilution, average during sampling period	NA		

3.2.5 Results to be reported by the laboratory				
Question	Answer		Comments	
Satisfactory temperature at arrival	Yes/No			
Sampling bottles and transportation container prepared by laboratory	Yes/No			
Methods within the scope of ISO 17025 accreditation of the laboratory	Yes/No			
Date and time samples arrived at laboratory				
Date and time of analyses				
Parameter	Bottle ID	Preparation method	Analytical method	Result + unit
Polycyclic Aromatic Hydrocarbons (PAH): 16 EPA PAHs: Acenaphthene Acenaphthylene Anthracene Benzo-a-anthracene Benzo-a-pyrene Benzo-b-fluoranthene Benzo-g,h,i-perylene Benzo-k-fluoranthene Chrysene Dibenzo-a,h-anthracene Fluoranthene Fluorene Indeno-1,2,3-c,d-pyrene Naphthalene Phenanthrene Pyrene				
Hydrocarbon Oil Index GC-FID analysis				
Nitrate and nitrite (NO_3^-/NO_2^-)				

Total Metals: - Cd - Cu - Ni - Pb - Zn - As - Cr - V - Se				
Dissolved Metals: - Cd - Cu - Ni - Pb - Zn - As - Cr - V - Se				

3.2.6 List of bottle IDs or chain of custody (COC)

Sampling point	Parameter PAH	Parameter Metals	Parameter X
Inlet	Bottle #1 + time stamp	Bottle #2 + time stamp	Etc.
discharge point	Bottle # + time stamp	Bottle # + time stamp	Etc.
Etc.	Etc.	Etc.	Etc.

APPENDIX 4

STANDARD SEAWATER TITRATION CURVE

1 The following is a description of the chemical equilibrium model and the resulting titration curve shown in the graph below (figure 1 for pure seawater). The equilibrium model may include the effect of adding an additional alkali to the seawater (e.g. NaOH).

2 The titration curve in figure 1 is prepared by using a chemical equilibrium model for seawater. The model includes inorganic carbon, boric acid, sulphate, fluoride and dissolved SO_2 equilibria; the equilibrium constants are functions of salinity (ionic strength) and temperature. The apparent pKa values for the equilibrium reactions are found in general oceanography literature, e.g. *An Introduction to the Chemistry of the Sea,* Michael E.Q. Pilson, Cambridge University Press (2013), and in the publication "The solubility of SO_2 and the dissociation of H_2SO_3 in NaCl solutions", F. Millero, P. Hershey, G. Johnson and J. Zhang, *Journal of Atmospheric Chemistry*, 8 (1989). pH is given on the NBS scale.

3 Basis for the computed curve:

.1 Released CO_2 retained in solution, i.e. no forced stripping of CO_2;

.2 10% of dissolved S(IV) oxidized to S(VI) inside EGCS;

.3 Seawater alkalinity 2.2 mmol/L;

.4 Seawater salinity 35 psu;

.5 Seawater pH 8.2; and

.6 Seawater temperature 32°C.

4 Fit equation. The fit equation for pure seawater is provided based on an empirical equation fit to the EM curve. The equation is:

$$pH = 3.84 - 0.2308 \cdot SO_2 + \frac{1.403}{\left(0.0403 + exp\left(2.966 \cdot (SO_2 - 0.189)\right)\right)} + \frac{9.947}{\left(4.605 + exp\left(4.554 \cdot (SO_2 - 1.588)\right)\right)}$$

where the variable SO_2 is defined as SO_2 absorbed in mmol/kg seawater.

The "fit equation" is used for the determination of the dilution factor.

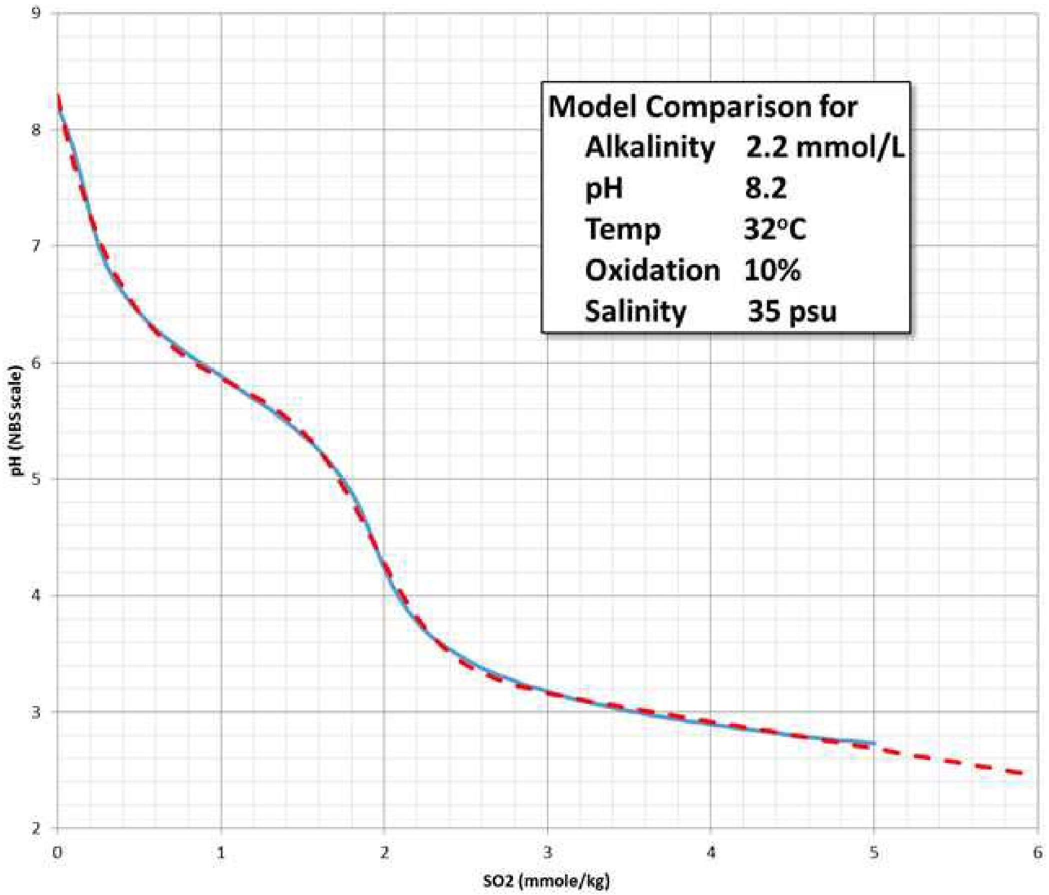


Figure 1 – pure seawater titration curve

APPENDIX 5

ANALYSER INFORMATION TEMPLATES

Under subsection 8.2 of these Guidelines certain information, as a minimum, should be included in the OMM in order to facilitate surveys and inspections.

Paragraph 8.2.4 requires that information should be given in respect of the exhaust gas and discharge water analysers used in the respective monitoring systems. In order to provide a common approach to the layout and detail which should be included, the following templates are provided and may be used in the OMM. These templates represent the minimum information which should be given. Additional information may be required by the Administration.

The use of these templates is voluntary; however, a standardized layout will assist all users of the OMM.

Exhaust gas

SO_2 / CO_2 measurement Where common, so indicate		
Analyser	SO_2	CO_2
Analyser manufacturer		
Model reference		
Onboard identification reference		
Arrangement	In situ/extractive	In situ/extractive
Probe location		
Probe description	(i.e. probe length, single/multiple hole/heated filter/heated pump)	(i.e. probe length, single/ multiple hole/heated filter/ heated pump)
Maximum measurement range	ppm	%
Used measurement range(s)	ppm	%
Zero gas specification		
Span gas specification		
Details of: service, maintenance, calibration schedules	Task/interval	Task/interval
Additional information		
Extractive systems only:		
Application	Single or multiple exhaust ducts (if multiple – state which ducts covered and sampling sequence, residence and purge times)	Single or multiple exhaust ducts (if multiple – state which ducts covered and sampling sequence, residence and purge times)

Sample line heated (if yes – maintained temperature °C)	Yes/No	Yes/No
Sample line details	Length, inner diameter	Length, inner diameter
Cooler/dryer: Manufacturer Model reference		
Additional information		

Water monitoring

pH/PAH/Turbidity* *delete as applicable	
Application	Seawater inlet/discharge water*
Analyser manufacturer	
Model reference	
Onboard identification reference	
Arrangement	In situ/bypass*
Position of sensor	
Maximum measurement range/units	
Used measurement range(s)/units	
Calibration fluid(s) – specification/ concentration/units	
Details of: service, maintenance, calibration schedules	Task/interval
Additional information	

***

ANNEX 2

RESOLUTION MEPC.341(77)
(adopted on 26 November 2021)

STRATEGY TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE

RECALLING Article 38(e) of the Convention on the International Maritime Organization (the 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,

ACKNOWLEDGING that work to prevent pollution by garbage from ships has been undertaken by the Organization since the adoption of MARPOL Annex V,

ACKNOWLEDGING ALSO the relevance of the work on marine plastic litter undertaken by the Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 and its 1996 Protocol, including the adoption in 2016 of a "Recommendation to Encourage Action to Combat Marine Litter",

ACKNOWLEDGING FURTHER the relevant work of other international organizations in relation to marine plastic litter, in particular FAO and UNEP and work under the United Nations Environment Assembly, as well as the importance of existing advisory and cooperation mechanisms, including GESAMP, the Joint FAO/IMO Ad Hoc Working Group on IUU Fishing and Related Matters, and the Global Partnership for Marine Litter,

RECALLING the United Nations 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal (SDG) 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development,

RECALLING ALSO that the Assembly, at its thirtieth session, in December 2017, recognized the ongoing problem of marine plastic pollution, as addressed in MARPOL Annex V, which required further consideration as part of a global solution within the framework of ocean governance, in pursuance of the target of SDG 14 to prevent and significantly reduce marine pollution of all kinds by 2025,

RECALLING FURTHER resolution MEPC.310(73) by which it adopted the Action Plan to Address Marine Plastic Litter from Ships (the Action Plan),

1 ADOPTS the Strategy to Address Marine Plastic Litter from Ships (the Strategy) to guide, monitor and oversee the timely and effective implementation of the Action Plan, as set out in the annex to the present resolution;

2 INVITES the Secretary-General of the Organization to make adequate provisions in the Integrated Technical Cooperation Programme (ITCP) to support relevant follow-up actions of the Strategy;

3 AGREES to undertake a review of the Strategy in 2025 and notes that a review of the actions within the Action Plan will be undertaken in 2023.

ANNEX

STRATEGY TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS

1 Background

1.1 IMO has recognized the importance of preventing pollution by garbage, including plastics, from ships since the adoption of MARPOL Annex V. IMO has also recognized the importance of preventing the dumping of various types of waste, including plastics, into the sea through the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention or LC) and its 1996 Protocol (London Protocol or LP). IMO has also committed to working closely with a number of partners to address the issue of marine plastic litter. However, studies demonstrate that, despite the existing regulatory framework to prevent marine plastic litter from ships, discharges into the sea continue to occur.

1.2 IMO recognized the ongoing problem of marine plastic pollution required further consideration, in pursuance of the target of Sustainable Development Goal 14 to prevent and significantly reduce marine pollution of all kinds by 2025. In recognition of the urgency to address marine plastic litter from ships, IMO adopted the *Action Plan to Address Marine Plastic Litter from Ships* (resolution MEPC.310(73)).

2 Vision

2.1 IMO remains committed to reducing marine plastic litter entering the marine environment from all ships, including fishing vessels. As a matter of urgency, IMO aims to strengthen the international framework and compliance with the relevant IMO instruments, endeavouring to achieve zero plastic waste discharges to sea from ships by 2025.

3 Objective and outcomes

3.1 The objective of this Strategy is to guide the implementation of the Action Plan to best achieve the outcomes of the Action Plan, by the establishment of a timeline and identification of appropriate modalities.

3.2 In considering the Action Plan, it is useful to consider the following outcomes as key goals:

.1 reduction of marine plastic litter generated from, and retrieved by, fishing vessels;

.2 reduction of shipping's contribution to marine plastic litter; and

.3 improvement of the effectiveness of port reception and facilities and treatment in reducing marine plastic litter;

and the following further efforts which could aid in achieving the goals, inter alia:

.4 enhanced public awareness, education and seafarer training;

.5 improved understanding of the contribution of ships to marine plastic litter;

.6 improved understanding of the regulatory framework associated with marine plastic litter from ships;

.7 strengthened international cooperation; and

.8 targeted technical cooperation and capacity-building.

4 Time frame

4.1 The following groups of actions under the Action Plan have been identified:

.1 actions that can be progressed now by relevant sub-committees, which could be referred to as short-term actions;

.2 actions that may be reliant on the outcomes of the IMO Study on marine plastic litter, or other relevant research, in order to progress, which could be referred to as mid-term actions;

.3 actions which require concrete proposals to the Committee in order to progress, and could therefore be considered long-term actions; and

.4 actions which would continuously be addressed over the life of the Action Plan.

4.2 The table grouping short-, mid-, long-term and continuous actions is set out in annex 1.

4.3 In line with the time frames provided in Sustainable Development Goal 14, the actions of the Action Plan should be completed or in progress by 2025. The time frame and actions associated with progressing short-, mid-, long-term and continuous actions; the IMO Study on Marine Plastic Litter; and the review and evaluation of actions up to 2025; is set out in annex 2.

5 Method of work

5.1 The impact on small island developing States and on remote locations such as polar regions when planning for the discharge of waste to land-based facilities (action item 18), should be considered when progressing each individual action related to addressing the discharge of plastic litter to reception facilities.

5.2 The actions in the Action Plan will be reviewed at MEPC based on follow-up proposals and commenting documents by interested Member States and international organizations. Following such a review, the Committee would instruct the PPR Sub-Committee or other sub-committees, as appropriate, to undertake work only on actions for which a well-defined scope of work had been developed.

5.3 During the ongoing development of the Action Plan, consideration should be given to how to assess compliance and effectiveness of actions.

5.4 For actions where the coordinating/associated organ is a sub-committee under MSC, the preferred way forward will be for proposals for a new output to be submitted to MSC in order for MSC to instruct the appropriate sub-committee accordingly.

5.5 For actions where the coordinating/associated organ is another committee, submission of documents to the relevant committee will be the preferred way forward.

6 Monitoring, evaluation and review

6.1 This Strategy will be monitored and evaluated to ensure that it continues to deliver against its objective and outcomes. In this regard, IMO will carry out a comprehensive review of the Strategy in 2025.

6.2 In accordance with resolution MEPC.310(73), IMO will also undertake a review of the Action Plan in 2023.

ANNEX 1

GROUPING OF SHORT-, MID-, LONG-TERM AND CONTINUOUS ACTIONS OF THE ACTION PLAN TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS

	Outcome	Actions
Short-term actions		
4	**Reduction of marine plastic litter generated from, and retrieved by, fishing vessels**	Preparation of a circular reminding IMO Member States to collect information from their registered fishing vessels regarding any discharge or accidental loss of fishing gear
7		Review the application of placards, garbage management plans and garbage record-keeping (regulation 10, MARPOL Annex V), for example making the Garbage Record Book mandatory for ships of 100 GT and above
8		Preparation of a circular reminding Member States to enforce MARPOL Annex V on fishing vessels through PSC measures Encourage port State control MoUs to develop PSC procedures that include fishing vessels
9	**Reduction of shipping's contribution to marine plastic litter**	Review the application of placards, garbage management plans and garbage record-keeping (regulation 10, MARPOL Annex V), for example making the Garbage Record Book mandatory for ships of 100 GT and above
10		Consider the establishment of a compulsory system of formatted declarations of the loss of containers and the means on board to easily identify the exact number of losses Also, consider establishing an obligation to report through a standardized procedure the loss of containers
11		Consider ways to communicate the location of containers lost overboard based on additional information to be provided by interested parties
13		Consider enhancing the enforcement of MARPOL Annex V, including, where possible, through a risk-based approach
17	**Improvement of the effectiveness of port reception and facilities and treatment in reducing marine plastic litter**	IMO to encourage Member States to effectively implement their obligation to provide adequate facilities at ports and terminals for the reception of garbage, as required by regulation 8 of MARPOL Annex V Take into consideration work being undertaken under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention or LC) and its 1996 Protocol (London Protocol or LP) (LC/LP) on this issue
19	**Enhanced public awareness, education and seafarer training**	Consider ways to promote the work of IMO to address marine plastic litter generated from ships

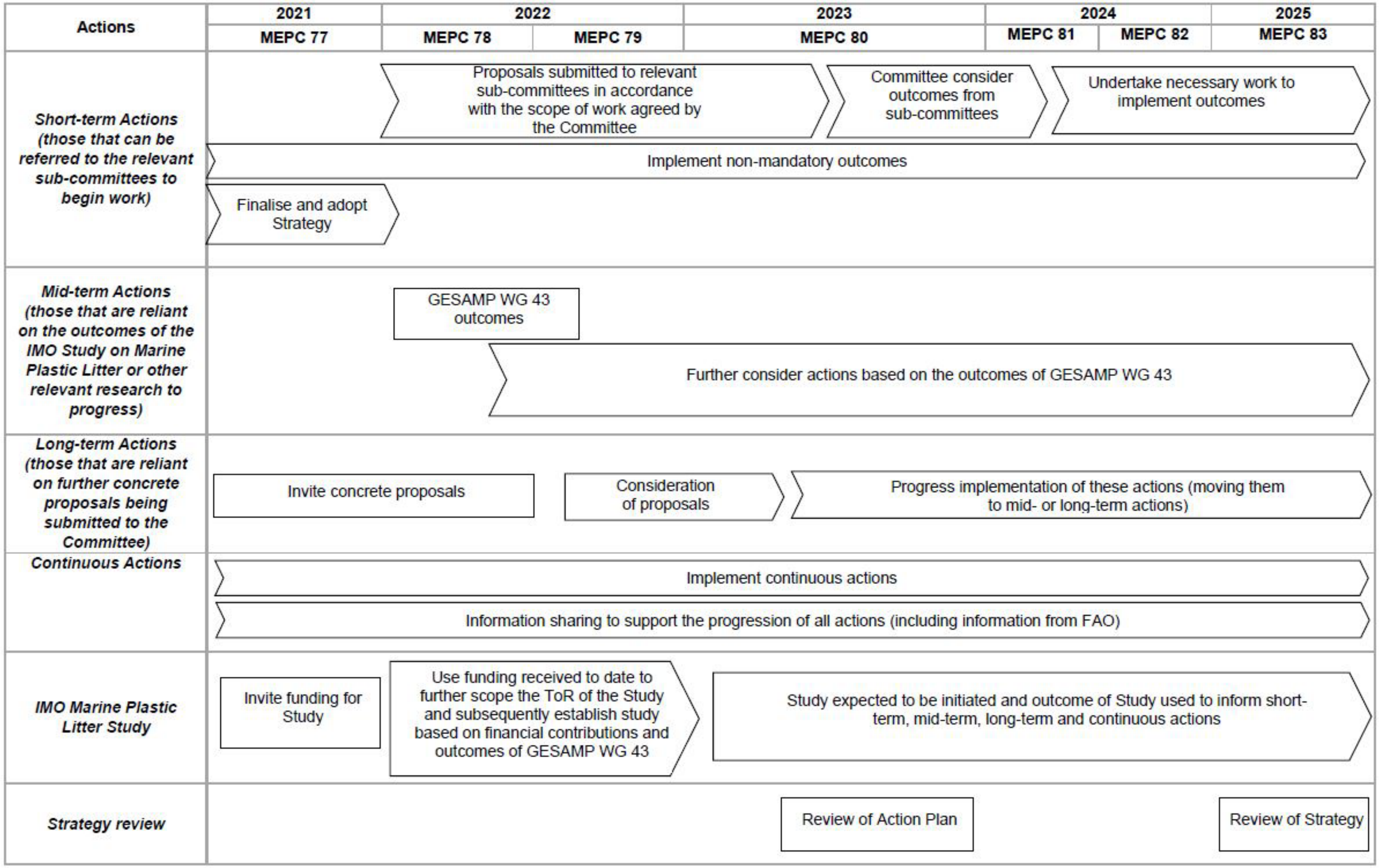
	Outcome	Actions
20		Consider tasking the HTW Sub-Committee with reviewing chapter III of STCW-F (Basic safety training for all fishing vessel personnel) to ensure that all fishing vessel personnel, before being assigned any shipboard duties, receive basic training on marine environment awareness oriented on marine plastic litter including abandoned, lost or otherwise discarded fishing gear (ALDFG)
21		Consider how the model course "Marine Environmental Awareness 1.38" could be amended/revised to specifically address marine plastic litter Further consider how to ensure familiarization of all seafarers within the existing STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) minimum requirements and taking into account existing best practice, guidelines and programmes
22	**Improved understanding of the contribution of ships to marine plastic litter**	Consider extending the reporting requirement in regulation 10.6 of MARPOL Annex V to include reporting data on discharge or accidental loss of fishing gear by the flag State to IMO via GISIS or other means, if appropriate
23		Encourage Member States and international organizations that have conducted any scientific research related to marine litter to share the results of such research, including any information on the areas contaminated by marine litter from ships
24		Conduct a study on marine plastic litter, including macro and microplastics, from all ships
25		Invite Member States and international organizations to undertake studies to better understand microplastics from ships
26	**Improved understanding of the regulatory framework associated with marine plastic litter from ships**	Consider the development of a regulatory framework matrix for the purpose of a gap analysis
27	**Strengthened international cooperation**	Make information available to the United Nations Environment Assembly (UNEA)
28		Continue work with other United Nations bodies and agencies, as well as with international forums, which are active in the matter of marine plastic litter from shipping, such as through the Global Partnership on Marine Litter (GPML)
Mid-term actions		
2		Consider making mandatory, through an appropriate IMO instrument (e.g. MARPOL Annex V), the marking of fishing gear with the IMO Ship Identification Number, in cooperation with the Food and Agriculture Organization of the United Nations (FAO)

	Outcome	Actions
3		Further investigate logging of the identification number for each item of fishing gear on board a fishing vessel
5		Consider the development of best management practice to facilitate incentives for fishing vessels to retrieve derelict fishing gear and deliver it to port reception facilities, in collaboration with FAO
6		Consider the issue of waste that has been collected during fishing operations building on experience gathered from established projects
14	**Improvement of the effectiveness of port reception and facilities and treatment in reducing marine plastic litter**	Consider the requirement for port reception facilities to provide for separate garbage collection for plastic waste from ships, including fishing gear to facilitate reuse or recycling
15	**Improvement of the effectiveness of port reception and facilities and treatment in reducing marine plastic litter**	Consider mechanisms to enhance the enforcement of MARPOL Annex V requirements for the delivery of garbage to reception facilities
16		Consider the development of tools to support the implementation of cost frameworks associated with port reception facilities, taking into account the need to not create disincentives for the use of port reception facilities, the potential benefits of cost incentives that provide no additional fees based on volume and identifying waste types that can be reduced, reused or recycled through schemes that identify waste revenue
17		Consider facilitating the mandatory use of port waste management plans to ensure the provision of adequate waste reception facilities Encourage Member States to address the entire process of plastic garbage handling and ensure that landed garbage is managed in a sustainable manner ashore Identify information from the port waste management plans that can be shared via the Global Integrated Shipping Information System (GISIS)
18		Further consider the impact on small island developing States and on remote locations such as polar regions when planning for the disposal of waste to land-based facilities
Long-term actions		
1	**Reduction of marine plastic litter generated from, and retrieved by, fishing vessels**	Consider making the IMO Ship Identification Number Scheme mandatory for all fishing vessels over 24 metres in length through an amendment to the Cape Town Agreement once it enters into force Encourage the ratification of the Cape Town agreement

	Outcome	Actions
12	**Reduction of shipping's contribution to marine plastic litter**	Consider the most appropriate instrument to address the responsibility and liability for plastic consumer goods lost at sea from ships
Continuous actions		
29	**Targeted technical cooperation and capacity-building**	Address implementation issues related to the Action Plan to Address Marine Plastic Litter from Ships in the context of IMO technical cooperation and capacity-building activities
30		Consider the establishment of externally funded major projects under the auspices of IMO in support of the action plan to address marine plastic litter from ships
1	**Reduction of marine plastic litter generated from, and retrieved by, fishing vessels**	Encourage the ratification of the Cape Town agreement

ANNEX 2

TIMELINE OF FOLLOW-UP ACTIONS FOR THE ACTION PLAN TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS



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MEPC.1/Circ.883/Rev.1
15 December 2021

GUIDANCE ON INDICATION OF ONGOING COMPLIANCE IN THE CASE OF THE FAILURE OF A SINGLE MONITORING INSTRUMENT, AND RECOMMENDED ACTIONS TO TAKE IF THE EXHAUST GAS CLEANING SYSTEM (EGCS) FAILS TO MEET THE PROVISIONS OF THE EGCS GUIDELINES

1 The Marine Environment Protection Committee, at its seventy-fourth session (13 to 17 May 2019), approved the *Guidance on indication of ongoing compliance in the case of the failure of a single monitoring instrument, and recommended actions to take if the exhaust gas cleaning system (EGCS) fails to meet the provisions of the 2015 EGCS Guidelines (resolution MEPC.259(68))* (MEPC.1/Circ.883).

2 The Marine Environment Protection Committee, at its seventy-seventh session (22 to 26 November 2021), adopted resolution MEPC.340(77) on *2021 Guidelines for exhaust gas cleaning systems* (2021 EGCS Guidelines).

3 Recognizing the need to extend the scope of MEPC.1/Circ.883 to also include the EGCS installed in accordance with resolution MEPC.184(59), the 2009 EGCS Guidelines, and resolution MEPC.340(77), the 2021 EGCS Guidelines, MEPC 77 approved the *Guidance on indication of ongoing compliance in the case of the failure of a single monitoring instrument, and recommended actions to take if the exhaust gas cleaning system (EGCS) fails to meet the provisions of the EGCS Guidelines*, set out in the annex.

4 Member Governments are invited to bring the annexed Guidance to the attention of Administrations, port State control authorities, industry, relevant shipping organizations, shipping companies and other stakeholders concerned.

5 This circular revokes MEPC.1/Circ.883.

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ANNEX

GUIDANCE ON INDICATION OF ONGOING COMPLIANCE IN THE CASE OF THE FAILURE OF A SINGLE MONITORING INSTRUMENT, AND RECOMMENDED ACTIONS TO TAKE IF THE EGCS FAILS TO MEET THE PROVISIONS OF THE EGCS GUIDELINES[1]

System malfunction

1 An Exhaust Gas Cleaning System (EGCS) malfunction is any condition that leads to an emission exceedance, with the exception of the short-term temporary emission exceedance cases described in sections 7 and 8, or an interim indication of ongoing compliance in the case of sensor failure described in sections 9 to 11.

2 As soon as possible after evidence of a malfunction (e.g. alarm is triggered), the ship should take action to identify and remedy the malfunction.

3 The ship operator should follow the process to identify and remedy the malfunction in the Exhaust Gas Cleaning System – Technical Manual that is approved at the time the EGCS is certified or in other documentation provided by the EGCS manufacturer.

4 The trouble-shooting process specified by the EGCS manufacturer should describe how to determine, within a reasonable amount of time, if the system itself is not working properly and whether the system fault must be addressed through adjustment and/or repair. The procedure would describe events that can trigger a monitoring alarm or other evidence of a scrubber malfunction (e.g. pump flow rates) and the troubleshooting process to identify and remedy the malfunction. The process should include at a minimum the following:

.1 a checklist for the operator to use to identify a malfunction; and

.2 a list of remedial actions that can be taken to resolve the malfunction after it is identified.

5 An EGCS malfunction event should be recorded in the EGCS Record Book including the date and time the malfunction began, the duration of the malfunction and, if relevant, how it was resolved, the actions taken to resolve it and any necessary follow-up actions.

6 A system malfunction that cannot be rectified is regarded as a breakdown. The ship should then change over to compliant fuel oil if the EGCS cannot be put back into a compliant condition within a maximum of one hour. If the ship does not have compliant fuel oil or sufficient amount of compliant fuel oil on board, a proposed course of action, in order to bunker compliant fuel oil or carry out repair works, should be communicated to relevant authorities including the ship's Administration and relevant port State for their agreement.

Short-term exceedances

7 A short-term temporary emission exceedance is an event where the maximum applicable Emissions Ratio is exceeded for a short period. This short period of non-compliance may be due to sudden changes in exhaust gas flow rate or the EGCS's sensor dynamic response. A time lapse between when the sensor takes its reading and when the unit responds may trigger an alarm from the continuous emission monitoring device even though the EGCS

[1] Resolutions MEPC.184(59), MEPC.259(68) and MEPC.340(77).

has not malfunctioned. Thus, transitory periods of emission exceedances and/or isolated spikes in the recorded output in the Emissions Ratio do not necessarily mean non-compliant exceedance of emissions and should therefore not be considered as a breach of the requirements.

8 The typical operating conditions that may result in a short-term temporary emission exceedance and the limits of these exceedances should be specified by the EGCS manufacturer in the EGCS Technical Manual that is approved at the time the EGCS is certified.

Interim indication of ongoing compliance in the case of sensor failure

9 When running on a fuel oil with a constant sulphur content and at constant washwater flow rate to engine load ratio, all parameters monitored according to the EGCS Guidelines[2] (i.e. Emission Ratio, washwater pH, etc.) will be in a certain interrelation, all depending on each other. If one of the parameters changes significantly, some other(s) may also have to change.

10 This interrelation also serves as an indicator of instrumentation malfunction; i.e. if a single sensor signal starts to deviate or even does not display, the effect on the other parameters may indicate whether the change in signal is caused by sensor failure or whether the performance of the EGCS itself has changed. If the other parameters are continuing at normal levels, it is a possible indication that there is only an instrumentation malfunction rather than a non-compliance with regard to the levels allowed in the exhaust gas and the discharge water.

11 If a malfunction occurs in the instrumentation for the monitoring of Emission Ratio or discharge water (pH, PAH, Turbidity), the ship should keep records of interim indication for demonstrating compliance. The documentation and actions should include (but are not limited to):

.1 the manual or automatic recording of the data at the time of malfunction may be used to confirm that all other relevant data as recorded for the performance of the EGCS are showing values in line with values prior to the malfunction;

.2 the ship operator should record the sulphur content of the various grades of fuel oil used in the affected fuel oil combustion units from the time when the malfunction started;

.3 the ship operator should log the malfunctioning of the monitoring equipment and (for Scheme A) record all parameters that might be suitable to indicate compliant operation. This record could serve as an alternative documentation demonstrating compliance until the malfunction is rectified; and

.4 the monitoring equipment that has suffered a malfunction should be repaired or replaced as soon as practicable.

[2] Resolutions MEPC.184(59), MEPC.259(68) and MEPC.340(77).

Notifications to relevant Authorities

12 Any EGCS malfunction that lasts more than one hour or repetitive malfunctions should be reported to the Flag Administration and the port State's Administration along with an explanation of the steps the ship operator is taking to address the failure. At their discretion, the Flag Administration could take such information and other relevant circumstances into account to determine the appropriate action to take in the case of an EGCS malfunction. Should the ship exceptionally need to continue on its intended voyage in a non-compliant condition, this should be communicated to the relevant port State to decide on appropriate action in accordance with the Convention.

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MEPC.1/Circ.896
14 December 2021

2021 GUIDANCE ON TREATMENT OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES FOR CALCULATION AND VERIFICATION OF THE ATTAINED EEDI AND EEXI

1 The Marine Environment Protection Committee, at its seventy-seventh session (22 to 26 November 2021), approved the *2021 Guidance on treatment of innovative energy efficiency technologies for calculation and verification of the attained EEDI and EEXI*, as set out in the annex.

2 Member Governments are invited to bring the annexed Guidance to the attention of their Administrations, industry, relevant shipping organizations, shipping companies and other stakeholders concerned.

3 The Committee agreed to keep this Guidance under review in light of experience gained in its application.

4 This circular supersedes MEPC.1/Circ.815.

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ANNEX

2021 GUIDANCE ON TREATMENT OF INNOVATIVE ENERGY EFFICIENCY TECHNOLOGIES FOR CALCULATION AND VERIFICATION OF THE ATTAINED EEDI AND EEXI

TABLE OF CONTENTS

1 General

1.1 The purpose of this guidance is to assist manufacturers, shipbuilders, shipowners, verifiers and other interested parties relating to Energy Efficiency Design Index (EEDI) and Energy Efficiency Existing Ship Index (EEXI) of ships to treat innovative energy efficiency technologies for calculation and verification of the attained EEDI, in accordance with regulations 5, 6, 7, 8, 9 and 20 of Annex VI to MARPOL. Although the term EEDI only is used through the whole guidance, it applies to both the EEDI and the EEXI calculations, as applicable.

1.2 There are EEDI Calculation Guidelines and EEDI Survey Guidelines. This guidance does not intend to supersede those guidelines but provides the methodology of calculation, survey and certification of innovative energy efficiency technologies, which are not covered by those guidelines. In the case that there are inconsistencies between this guidance and these guidelines, those guidelines should take precedence.

1.3 This guidance might not provide sufficient measures of calculation and verification for ships with diesel-electric propulsion, turbine propulsion and hybrid propulsion systems on the grounds that the attained EEDI Formula shown in EEDI Calculation Guidelines may not be able to apply to such propulsion systems.

1.4 The guidance should be reviewed for the inclusion of new innovative technologies not yet covered by the guidance.

1.5 The guidance also should be reviewed, after accumulating the experiences of each innovative technology, in order to make it more robust and effective, using the feedback from actual operating data. Therefore, it is advisable that the effect of each innovative technology in actual operating conditions should be monitored and collected for future improvement of this guidance document.

2 Definitions

2.1 *EEDI Calculation Guidelines* means *2018 guidelines on the method of calculation of the attained energy efficiency design index (EEDI) for new ships* (resolution MEPC.308(73), as amended).

2.2 *EEDI Survey Guidelines* means *2014 guidelines on survey and certification of the energy efficiency design index (EEDI)* (resolution MEPC.254(67), as amended by resolution MEPC.261(68) and resolution MEPC.309(73)).

2.3 P_p is the propulsion power and is defined as ΣP_{ME} (In case where shaft motor(s) are installed, $\Sigma P_{ME} + \Sigma P_{PTI(i),\text{shaft}}$, as shown in paragraph 2.2.5.3 of EEDI Calculation Guidelines).

2.4 In addition to the above, definitions of the words in this guidance are the same as those of MARPOL Annex VI, EEDI Calculation Guidelines and EEDI Survey Guidelines.

3 Categorizing of Innovative Energy Efficiency Technologies

3.1 Innovative energy efficiency technologies are allocated to category (A), (B) and (C), depending on their characteristics and effects to the EEDI formula. Furthermore, innovative energy efficiency technologies of category (B) and (C) are categorized to two sub-categories (category (B-1) and (B-2), and (C-1) and (C-2), respectively).

Category (A): Technologies that shift the power curve, which results in the change of combination of P_P and V_{ref}: e.g. when V_{ref} is kept constant, P_P will be reduced and when P_P is kept constant, V_{ref} will be increased.

Category (B): Technologies that reduce the propulsion power, P_P, at V_{ref}, but do not generate electricity. The saved energy is counted as P_{eff}.

Category (B-1): Technologies which can be used at any time during the operation and thus the availability factor (f_{eff}) should be treated as 1.00.

Category (B-2): Technologies which can be used at their full output only under limited condition. The setting of availability factor (f_{eff}) should be less than 1.00.

Category (C): Technologies that generate electricity. The saved energy is counted as P_{AEeff}.

Category (C-1): Technologies which can be used at any time during the operation and thus the availability factor (f_{eff}) should be treated as 1.00.

Category (C-2): Technologies which can be used at their full output only under limited condition. The setting of availability factor (f_{eff}) should be less than 1.00.

(C) Emission reduction through the auxiliary power reduction by generating electricity for normal maximum sea load(P_{AEeff})

(B) Emission reduction through the propulsion power reduction (P_{eff})

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

(A) The combination of P_P and V_{ref} as reflected in the power curve (knot-kW curve)

Innovative Energy Efficiency Technologies				
Reduction of Main Engine Power			**Reduction of Auxiliary Power**	
Category A	***Category B-1***	***Category B-2***	***Category C-1***	***Category C-2***
Cannot be separated from overall performance of the vessel	Can be treated separately from the overall performance of the vessel		Effective at all time	Depending on ambient environment
	$f_{eff} = 1$	$f_{eff} < 1$	$f_{eff} = 1$	$f_{eff} < 1$
– low friction coating – bare optimization – rudder resistance – propeller design	– hull air lubrication system (air cavity via air injection to reduce ship resistance) (can be switched off)	– wind assistance (sails, Flettner-Rotors, kites)	– waste heat recovery system (exhaust gas heat recovery and conversion to electric power)	– photovoltaic cells

4 Calculation and Verification of effects of Innovative Energy Efficiency Technologies

4.1 General

4.1.1 The evaluation of the benefit of any innovative technology is to be carried out in conjunction with the hull form and propulsion system with which it is intended to be used. Results of model tests or sea trials of the innovative technology in conjunction with different hull forms or propulsion systems may not be applicable.

4.2 Category (A) technology

4.2.1 Innovative energy efficiency technologies in category (A) affect P_P and/or V_{ref} and their effects cannot be measured in isolation. Therefore, these effects should not be calculated nor certified in isolation in this guidance but should be treated as a part of vessel in EEDI Calculation Guidelines and EEDI Survey Guidelines.

4.3 Category (B) technology

4.3.1 The effects of innovative energy technologies in category (B) are expressed as P_{eff} which would be multiplied by C_{FME} and SFC_{ME} (in the case of $P_{PTI(i)}$ >0, the average weighted value of ($SFC_{ME} \cdot C_{FME}$) and ($SFC_{AE} \cdot C_{FAE}$)) and f_{eff}, and then be deducted from the EEDI formula. In the case of category (B-1) technology, f_{eff} is 1.00.

4.3.2 Guidance on calculation and verification of effects of Category (B) innovative technologies is given in annex 1.

4.4 Category (C) technology

4.4.1 The effects of innovative energy technologies in category (C) are expressed as P_{AEeff} which would be multiplied by C_{FAE}, SFC_{AE} and f_{eff}, and then be deducted from the EEDI formula. In the case of category (C-1) technology, f_{eff} is 1.00.

4.4.2 Guidance on calculation and verification of effects of Category (C) innovative technologies is given in annex 2.

4.5 Average weighted value in the case of $P_{PTI(i)}$ >0

4.5.1 In the case of $P_{PTI(i)}$ >0, both Category (B) and Category (C) technologies might deduct the value of $P_{PTI(i)}$. In such case, following values are to be used for average weighted value in calculating $\Sigma(f_{eff(i)} \cdot P_{eff(i)} \cdot C_{F.}\ SFC)$ in attained EEDI formula:

For shaft power(s):
$(\Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)}) \,/\, (\Sigma P_{ME(i)} + \Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)})$,
where, if $(\Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)})$ is taken negative value, the value $(\Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)})$ should be fixed to zero; and

For main engine(s):
$\Sigma P_{ME(i)} \,/\, (\Sigma P_{ME(i)} + \Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)})$,
where, if $\Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)}$ is taken negative value, the value $(\Sigma P_{PTI(i),shaft} - \cdot\Sigma P_{AEeff}\cdot\eta_{GEN}\cdot\eta_{PTI(i)})$ should be fixed to zero.

ANNEX 1[1]

GUIDANCE ON CALCULATION AND VERIFICATION OF EFFECTS OF CATEGORY (B) INNOVATIVE TECHNOLOGIES

1 AIR LUBRICATION SYSTEM (CATEGORY (B-1))

1.1 Summary of innovative energy efficient technology

1.1.1 An air lubrication system is one of the innovative energy efficiency technologies. Ship frictional resistance can be reduced by covering the ship surface with air bubbles, which is injected from the fore part of the ship bottom by using blowers, etc.

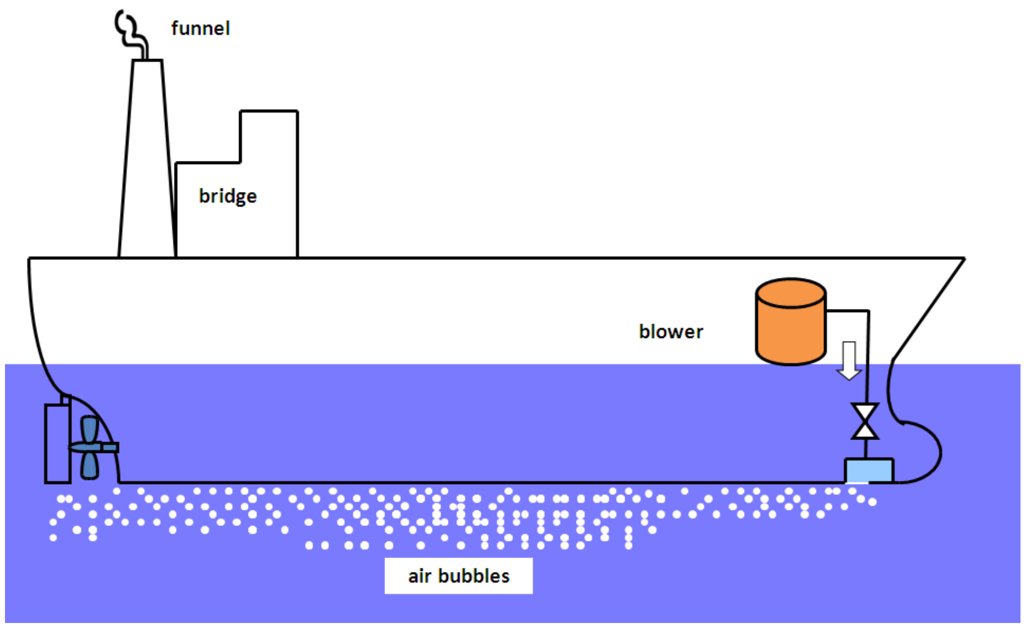

Figure 1 – Schematic illustration of an air lubrication system

1.2 Method of calculation

1.2.1 Power reduction due to air lubrication system

1.2.1.1 Power reduction factor P_{eff} due to an air lubrication system as an innovative energy efficiency technology is calculated by the following formula. The first and second terms of the right hand side represent the reduction of propulsion power by the air lubrication system and the additional power necessary for running the system, respectively. For this system, f_{eff} is 1.0 in EEDI formula.

$$P_{eff} = P_{PeffAL} - P_{AEeffAL} \frac{C_{FAE}}{C_{FME}} \frac{SFC_{AE}}{SFC_{ME}*} \qquad (1)$$

* In the case of $P_{PTI(i)}$ >0, the average weighted value of ($SFC_{ME} \cdot C_{FME}$) and ($SFC_{AE} \cdot C_{FAE}$)

1 All examples in this chapter are used solely to illustrate the proposed methods of calculation and verification.

1.2.1.2 P_{eff} is the effective power reduction in kW due to the air lubrication system at the 75% t of the rated installed power (MCR). In case that shaft generators are installed, P_{eff} should be calculated at the 75% MCR having after deducted any installed shaft generators in accordance with paragraph 2.2.5 of EEDI Calculation Guidelines. P_{eff} should be calculated both in the fully loaded and the sea trial conditions.

1.2.1.3 P_{PeffAL} is the reduction of propulsion power due to the air lubrication system in kW. P_{PeffAL} should be calculated both in the condition corresponding to the *Capacity* as defined in EEDI Calculation Guidelines (hereinafter referred to as "fully loaded condition") and the sea trial condition, taking the following items into account:

.1 area of ship surface covered with air;

.2 thickness of air layer;

.3 reduction rate of frictional resistance due to the coverage of air layer;

.4 change of propulsion efficiency due to the interaction with air bubbles (self-propulsion factors and propeller open water characteristics); and

.5 change of resistance due to additional device, if equipped.

1.2.1.4 $P_{AEeffAL}$ is additional auxiliary power in kW necessary for running the air lubrication system in the fully loaded condition. $P_{AEeffAL}$ should be calculated as 75% of the rated output of blowers based on the manufacturer's test report. For a system where the calculated value above is significantly different from the output used at normal operation in the fully loaded condition, the $P_{AEeffAL}$ value may be estimated by an alternative method. In this case, the calculation process should be submitted to a verifier.

1.2.2 Points to keep in mind in calculation of attained EEDI with air lubrication system

1.2.2.1 V_{ref} in paragraph 2.2.2 of EEDI Calculation Guidelines should be calculated in the condition that the air lubrication system is OFF to avoid the double count of the effect of this system.

1.2.2.2 In accordance with EEDI Calculation Guidelines, the EEDI value for ships for the air lubrication system ON should be calculated in the fully loaded condition.

1.3 Method of verification

1.3.1 General

1.3.1.1 Attained EEDI for a ship with an innovative energy efficient technology should be verified in accordance with EEDI Survey Guidelines. Additional information on the application of air lubrication system, which is not given in the EEDI Survey Guidelines, is contained below.

1.3.2 Preliminary verification at the design stage

1.3.2.1 In addition to paragraph 4.2.2 of EEDI Survey Guidelines, the EEDI Technical File, which is to be developed by a shipowner or shipbuilder, should include:

.1 outline of the air lubrication system;

.2 P_{PeffAL} : the reduction of propulsion power due to the air lubrication system at the ship speed of V_{ref} both in the fully loaded and the sea trial conditions;

.3 EDR_{full} : the reduction rate of propulsion power in the fully loaded condition due to the air lubrication system. EDR_{full} is calculated by dividing $P_{MEeffAL}$ by P_{ME} in EEDI Calculation Guidelines in the fully loaded condition (see figure 2);

.4 EDR_{trial} : the reduction rate of propulsion power in a sea trial condition due to the air lubrication system. EDR_{trial} is calculated by dividing $P_{MEeffAL}$ by P_{ME} in EEDI Calculation Guidelines in sea trial condition (see figure 2);

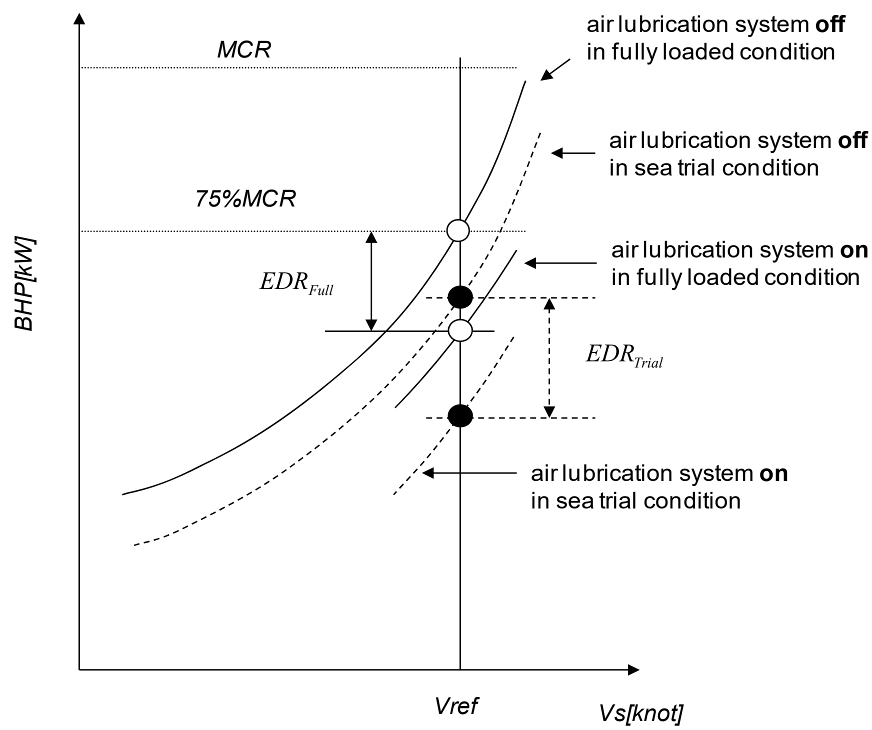

Figure 2 – Calculation of the reduction rate of propulsion power (EDR_{full} and EDR_{trial}) due to air lubrication system

.5 $P_{AEeffAL}$: additional power necessary for running the air lubrication system; and

.6 the calculated value of the EEDI for the air lubrication system ON in the fully loaded condition.

1.3.2.2 In addition with paragraph 4.2.7 of the EEDI Survey Guidelines, additional information that the verifier may request the shipbuilder to provide directly to it includes:

.1 the detailed calculation process of the reduction of propulsion power due to the air lubrication system: P_{PeffAL} ; and

.2 the detailed calculation process of the additional power necessary for running the air lubrication system: $P_{AEeffAL}$.

1.3.3 Final verification of the attained EEDI at sea trial

1.3.3.1 Final verification of the EEDI of ships due to the air lubrication system should be conducted at the sea trial. The procedure of final verification should be basically in accordance with paragraph 4.3 of the EEDI Survey Guidelines.

1.3.3.2 Prior to the sea trial, the following documents should be submitted to the verifier; a description of the test procedure that includes the measurement methods to be used at the sea trial of the ship with the air lubrication system.

1.3.3.3 The verifier should attend the sea trial and confirm the items described in paragraph 4.3.3 of the EEDI Survey Guidelines to be measured at the sea trial for the air lubrication system ON and OFF.

1.3.3.4 The main engine output at the sea trial for the air lubrication system ON and OFF should be set so that the range of the developed power curve includes the ship speed of V_{ref}.

1.3.3.5 The following procedure should be conducted based on the power curve developed for air lubrication system OFF.

.1 ship speed at 75% MCR of main engine in the fully loaded condition, V_{ref}, should be calculated. In case that shaft generators are installed, V_{ref} should be calculated at 75% MCR having after deducted any installed shaft generators in accordance with paragraph 2.2.5 of EEDI Calculation Guidelines; and

.2 in case that V_{ref} obtained above is different from that estimated at the design stage, the reduction rate of main engine should be recalculated at new V_{ref} both in the fully loaded and the sea trial conditions.

1.3.3.6 The shipbuilder should develop power curves for the air lubrication system ON based on the measured ship speed and output of the main engine at the sea trial. The following calculations should be conducted.

.1 the actual reduction rate of propulsion power ADR_{trial} at the ship speed of V_{ref} at the sea trial; and

.2 if the sea trial is not conducted in the fully loaded condition, the reduction rate of propulsion power in this condition should be calculated by the following formula:

$$1 - ADR_{Full} = (1 - EDR_{Full}) \times \frac{1 - ADR_{Trial}}{1 - EDR_{Trial}},$$

i.e.

$$ADR_{Full} = 1 - (1 - EDR_{Full}) \times \frac{1 - ADR_{Trial}}{1 - EDR_{Trial}} \qquad (2)$$

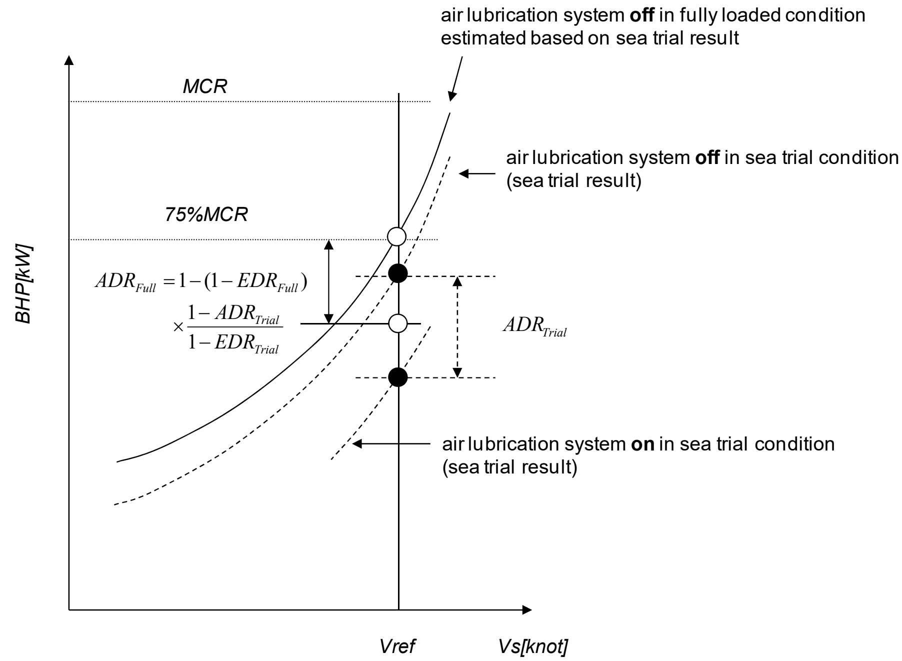

Figure 3 – Calculation of the actual reduction rate of propulsion power (ADR_{full} and ADR_{trial}) due to air lubrication system

1.3.3.7 The reduction of propulsion power due to the air lubrication system $P_{MEeffAL}$ in the fully loaded and the sea trial conditions should be calculated as follows:

$$P_{PeffAL\_Full} = ADR_{Full} \times P_P \quad (3)$$

$$P_{PeffAL\_Trial} = ADR_{Trial} \times P_P \quad (4)$$

1.3.3.8 The shipowner or the shipbuilder should revise the EEDI Technical File, as necessary, by taking the result of the sea trial into account. Such revision should include the following contents:

.1 V_{ref}, in case that it is different from that estimated at the design stage;

.2 the reduction of propulsion power P_{PeffAL} at the ship speed of V_{ref} in the fully loaded and the sea trial conditions for the air lubrication system ON;

.3 the reduction rate of propulsion power due to air lubrication system (ADR_{full} and ADR_{trial}) in the fully loaded and the sea trial conditions; and

.4 the calculated value of the EEDI for the air lubrication system ON in the fully loaded condition.

2 WIND ASSISTED PROPULSION SYSTEM (CATEGORY B-2)

2.1 Summary of innovative energy efficient technology

2.1.1 Wind assisted propulsion systems (WAPS) belong to innovative mechanical energy efficient technologies which reduce the CO_2 emissions of ships. There are different types of wind propulsion technologies (sails, wings, kites, etc.) which generate forces dependent on wind conditions. This technical guidance defines the available effective power of WAPS as the product of the reference speed and the sum of the wind assisted propulsion system force and the global wind probability distribution.

2.1.2 Secondary effects when applying the wind assisted propulsion system which might increase the ship resistance are ignored for the purpose of these guidelines. With this simplification effects as for instance additional drag due to leeway, rudder angle and heel or reduced propeller efficiency in light running condition are ignored without significant loss of accuracy. Nonetheless, the corresponding forces are considered to rule out conditions that do not allow a safe operation of the ship, for instance due to exceeding heel angles.

2.2 Definitions

2.2.1 For the purpose of these guidelines, the following definitions should apply:

.1 *available effective power* is the multiplication of effective power P_{eff} and availability factor f_{eff} , as defined in the EEDI calculation;

.2 *wind assisted propulsion systems (WAPS)* belong to innovative mechanical energy efficient technologies which reduce the CO_2 emissions of ships. These proposed guidelines apply to wind propulsion technologies that directly transfer mechanical propulsion forces to the ship's structure (sails, wings, kites, etc.);

.3 *wind propulsion system force matrix* is a two-dimensional matrix which expresses the force characteristic of a wind assisted propulsion system dependent on ship speed, wind speed and the wind angle relative to heading;

.4 *global wind probability matrix* contains data of the global wind power on the main global shipping routes based on a statistical survey of worldwide wind data and represents the probability of wind conditions;

.5 *wind speed* is the speed of the wind in m/s measured at 10 m above sea level;

.6 *wind direction* is the North-oriented direction of the wind measured at 10 m above sea level and is subdivided into eight sectors (North, North-East, East, South-East, South, South-West, West, North-West);

.7 *wind angle* is the angle of the wind relative to the ship's heading at 10 m above sea level subdivided into 72 sectors of 5°-steps (0°, 5°,..., 355°); and

.8 the *main global shipping network* is a network of global shipping routes with the highest frequency of journeys.

2.3 Available effective power of wind assisted propulsion systems (WAPS)

2.3.1 The available effective power of wind assisted propulsion systems as innovative energy efficient technology is calculated by the following formula:

$$(f_{eff} \cdot P_{eff}) = \left(\frac{1}{\sum_{k=1}^{q} W_k}\right) \cdot \left(\left(\frac{0.5144 \cdot V_{ref}}{\eta_D}\sum_{k=1}^{q} F(V_{ref})_k \cdot W_k\right) - \left(\sum_{k=1}^{q} P(V_{ref})_k \cdot W_k\right)\right)$$

with $F_1 - F_k \geq 0 \wedge F_{k-1} - F_k \geq 0$

(sorting all force matrix elements in descending order)

and $\sum_{k=1}^{q-1} W_k < \frac{1}{2} \wedge \sum_{k=1}^{q} W_k \geq \frac{1}{2}$
(defining q: the number of elements added in the formula)

Where:

.1 (f_{eff} * P_{eff}) is the available effective power in kW delivered by the specified wind assisted propulsion system. f_{eff} and P_{eff} are combined in the calculation because the product of availability and power is a result of a matrix operation, addressing each wind condition with a probability and a specific wind propulsion system force;

.2 the factor 0.5144 is the conversion factor from nautical miles per hour (knots) to metres per second (m/s);

.3 V_{ref} is the ship reference speed measured in nautical miles per hour (knots), as defined in the EEDI calculation guidelines.

.4 η_D is the total efficiency of the main drive(s) at 75% of the rated installed power (MCR) of the main engine(s). η_D shall be set to 0.7, if no other value is specified and verified by the verifier;

.5 $F(V_{ref})_k$ is the force matrix of the respective wind assisted propulsion system for a given ship speed V_{ref}. Each matrix element represents the propulsion force in kilo newton (kN) for the respective wind speed and angle. The wind angle is given in relative bearings (with 0° on the bow);

.6 W_k is the global wind probability matrix. Each matrix element represents the probability of wind speed and wind angle relative to the ships heading. The sum over all matrix elements equals 1 and is non-dimensional; and

.7 $P(V_{ref})_k$ is a matrix with the same dimensions as $F(V_{ref})_k$ and W_k and represents the power demand in kW for the operation of the wind assisted propulsion system.

2.3.2 The fore term of the formula defines the additional propulsion power to be considered for the overall EEDI calculation. The term contains the product of the ship specific speed, the force matrix and the global wind probability matrix. The aft term contains the power requirement for the operation of the specific wind assisted propulsion system which has to be subtracted from the gained wind power.

2.4 Wind propulsion system force matrix $F(V_{ref})_k$

2.4.1 Measurement of the wind propulsion coefficients

2.4.1.1 The wind propulsion system force matrix is a table describing the average wind propulsion coefficients corresponding to the global wind probability matrix. Therefore, the measurement of the wind propulsion coefficients has to be carried out at first in order to obtain the wind propulsion system force matrix.

2.4.1.2 Various methods can be used to determine the aerodynamic forces of a wind assisted ship, depending firstly on the type of wind assisted propulsion system, but also size limitations and successful validation for the methods already shown in literature. The methods include:

.1 wind tunnel model test;

.2 CFD/numerical calculations; and

.3 full scale test.

2.4.1.3 The forces are to be determined for the combination of wind assisted propulsion system and ship unless that is not practical due to technical or economic reasons. In the latter case the conditions of 2.4.1.4 apply.

2.4.1.4 In the case of the installation of multiple wind assisted propulsion systems, the forces may be determined for the devices in isolation and by the summing the coefficients of each units comprising the system, provided that a validated method is in place to account for interaction effects between wind propulsors and between the ship and the wind propulsors.

2.4.1.5 Wind propulsion devices are to be analysed at their operational Reynolds number, as this has been shown to affect their performance.

2.4.1.6 The wind tunnel model test is a major method for measuring the aerodynamic force of a wind assisted ship propulsion system under typical states. Appendix 1 of this annex describes the testing methods of wind tunnel model tests. If the wind propulsion coefficients are measured by the wind tunnel model test, it should be conducted in accordance with the appendix 1.

2.4.1.7 For some types of wind assisted propulsion system wind tunnel model tests are not appropriate for measuring the wind propulsion coefficients. Therefore, numerical calculations, such as CFD-computation, can be accepted for estimating the wind propulsion coefficients, but the condition and the model of the numerical calculation should be referred to experimental representative results and the numerical calculation is to be carried out in accordance with defined quality and technical standards (ITTC 7.5-03-01-02 and ITTC 7.5-03-01-04 at their latest revisions or equivalent). If both of wind tunnel model tests and numerical calculation are inappropriate to estimate the coefficient, other testing method may be acceptable with the approval of the verifier.

2.4.1.8 When a test or calculation for determining the wind propulsion coefficients is carried out, the procedure of the test or calculation should be submitted to the verifier in advance of conducting the test or calculation. In addition, the detail report of the test and calculation procedure should also be submitted to the verifier after the test. The verifier may request the submitter to provide further documents/information as necessary to verify the wind propulsion coefficients.

2.4.1.9 The test of a ship model without wind assisted propulsion system mainly measures the wind forces of the ship model pointing to the bow under different wind directions. The test of a ship model with wind assisted propulsion system mainly measures the maximum wind propulsion of the ship model pointing to the bow under different wind directions, which is then used to calculate the wind propulsion coefficient of the wind propulsion system. The coefficients of the wind assisted propulsion system should be determined at a series of wind angles ranging from 0° to 360°, spaced by an interval of 5°.

2.4.1.10 A single wind tunnel test may be accepted for several identical wind assisted propulsion systems and identical ships. The verifier may request that supporting documentation be produced.

2.4.2 Wind tunnel test methods and data processing

Option 1: Test on a ship model fitted with the full wind assisted propulsion system

2.4.2.1 When the wind tunnel test is carried out with the ship model and the wind assisted propulsion system model, the test method should follow the specifications given in appendix 1. The wind forces acting on the ship model are normalized as:

$$C_{Fx} = F_x / (0.5\ \rho\ V^2\ A)$$

2.4.2.2 The wind propulsion coefficients[2] of the wind assisted propulsion system can be determined as:

$$\Delta C_{Fx} = C_{Fx\text{-}with\ WPS} - C_{Fx\text{-}without\ WPS}$$

Where:

.1 C_{Fx} is the wind force coefficient of the model pointing to the bow;

.2 F_x is the wind force of the model pointing to the bow;

.3 ΔC_{Fx} is the wind propulsion coefficient of the wind assisted propulsion system;

.4 ρ is the air density of the model test;

.5 V is the wind velocity of the model test;

.6 A is the total projected area of the wind assisted propulsion system; and

.7 the subscript "with WAPS" means the state with wind assisted propulsion system of the ship model, while "without WAPS" means the state without wind assisted propulsion system of the ship.

[2] The force coefficients are dimensionless, the units for their calculation can be freely chosen, but must be consistent with each other.

Option 2: Test with a single wind assisted propulsion unit

2.4.2.3 When the wind tunnel test is carried out with a single wind propulsion unit, the test method should follow the specifications given in appendix 1. The wind propulsion coefficients[3] of the model can be determined as:

$$C_{Fx} = F_x / (0.5\ \rho\ V^2\ A)$$

Where:

.1 C_{Fx} is the wind force coefficient of the model pointing to the bow;

.2 F_x is the wind force of the model pointing to the bow;

.3 ρ is the air density of the model test;

.4 V is the wind velocity of the model test; and

.5 A is the total projected area of the wind assisted propulsion system.

2.4.2.4 The wind propulsion coefficients ΔC_{Fx} of a multi-unit wind assisted propulsion system can be calculated by summing the coefficients of the units comprising the system, weighted by the effects of interaction and masking by superstructures.

For options 1 and 2: Calculation of the average power consumption coefficients of the active wind assisted propulsion system during the wind tunnel test

2.4.2.5 The power consumption of the wind assisted propulsion system should be measured and the power consumption matrix should be filled based on the measured values and the systems control plan.

2.4.3 Calculation of the wind propulsion system force matrix

2.4.3.1 The wind propulsion coefficients[4] of the ship's wind assisted propulsion system can be used to predict the wind propulsion system force matrix. Apparent wind is defined as the combination of wind relative to the ground and wind created by the ship's velocity. The steps to calculate the wind propulsion system force matrix are as follows:

.1 determine the velocity of the ship V_{ref};

.2 select the average wind speed corresponding to terms in W_k, the global wind probability matrix at 10 m height. For example, the average wind speed corresponding to the first wind speed range (0-1 m/s) of the wind probability matrix is selected as 0.5 m/s, the average wind speed corresponding to the second wind speed range (1-2 m/s) is selected as 1.5 m/s, etc.;

.3 extrapolate the wind speed to the reference height of the wind assisted propulsion systems taken as the aerodynamic centre of effort height or half height from the waterline:

3 The force coefficients are dimensionless, the units for their calculation can be freely chosen, but must be consistent with each other.

4 The force coefficients are dimensionless, the units for their calculation can be freely chosen, but must be consistent with each other.

$$v_{Zref} = v_{10m}\left(\frac{z_{ref}}{10}\right)^{\alpha} \ for\ z_{ref} < 300m$$

$$v_{Zref} = v_{10m}\left(\frac{300}{10}\right)^{\alpha} \ for\ z_{ref} \geq 300m$$

Where:

.1 z_{ref} is the reference height above the water line, to be equal to the point of mid-height of each sail, Flettner, etc. in wind assisted propulsion system;

.2 v_{10m} is the wind velocity at 10 m above sea level;

.3 v_{Zref} is the resulting wind velocity at the reference height; and

.4 α is taken as 1/9 conforming to ITTC recommendations.[5]

.4 according to the corresponding average wind speed, wind direction angle and the velocity of the ship, calculate the relative wind speed V_k and the relative wind direction angle of the ship;

.5 according to the relative wind direction angle, and the corresponding relationship between the relative wind direction angle and the wind propulsion coefficient ΔC_{Fx} obtained from the test, calculate the average wind propulsion coefficients $(\Delta C_{Fx})_k$ of the wind assisted propulsion system corresponding to W_k; and

.6 according to the average wind propulsion coefficient of the wind assisted propulsion system, calculate the terms of the wind propulsion system force matrix $F(V_{ref})_k$ of the full scale ship corresponding to W_k by following formula:

$F(V_{ref})_k = (\Delta C_{Fx})_k * (0.5\ \rho\ V_k^2\ A)$

Where:

.1 $(\Delta C_{Fx})_k$ is the average wind propulsion coefficients corresponding to W_k;

.2 ρ is the average air density in shipping environment, ρ=1.225 kg/m^3;

.3 V_k is the relative wind velocity of the full-scale ship corresponding to W_k;

.4 A is the total projected area of the wind assisted propulsion system;

.5 the settings of the wind propulsor may be varied in order to find the best $(\Delta CFx)_k$; this may be done using interpolation provided that increments in settings are sufficiently small;

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5 International Towing Tank Conference (ITTC), "ITTC – Recommended Procedures and Guidelines; Preparation, Conduct and Analysis of Speed/Power Trial," International Towing Tank Conference (ITTC), 7.5-04-01-01.1, 2017.

Annotation: ITCC provides no guidance for wind speeds above an altitude above 300 m. However, it is assumed in this guideline to be constant above 300 m altitude.

.6 the settings and deployment of the wind assisted propulsion system must adhere to the operational constraints as defined for the system (e.g. a maximum operational wind speed, if lower than provided by the global wind probability matrix, > Bf 8, 19 m/s);

.7 the potential wind drag induced by the system is to be accounted for, such as in unusable wind directions close to head wind and when the systems is not operational due to exceedance of operational limits; and

.8 if $F(V_{ref})_k$ exceeds the resistance of the ship, such that the propeller thrust would be negative, $F(V_{ref})_k$ is to be limited at the resistance value.

2.4.4 Consideration of the operational limits of the wind assisted propulsion system and the lateral forces and yawing moments

2.4.4.1 Force $F(V_{ref})_k$ must be calculated only when it is within the operational domain applicable to the wind assisted propulsion system. These operational limitations can be caused at a minimum by wind conditions or by the total forces generated by the wind assisted propulsion system and applied to the ship.

2.4.4.2 $F(V_{ref})_k$ must be zero for any pair (wind direction; wind force) not in conformity with the operational domain of the wind assisted propulsion system validated by the verifier in the operations manual of the wind assisted propulsion system and the ship.

2.4.4.3 The lateral forces exerted by the wind assisted propulsion system on the ship and the resulting yawing moment can affect the performance of the system, and therefore the EEDI calculation. The lateral forces on the ship and the yawing moments applied by the wind assisted propulsion system to the ship should therefore be documented by the shipbuilder and/or propulsion system manufacturer and observed by the verifier. They can be obtained without additional effort during the tests described in paragraph 2.4.1 of the present circular.

2.4.4.4 Conformity with the operational domain requires that for any pair (wind direction; wind force), and in consideration of the total forces generated by the wind assisted propulsion system (i.e. including lateral forces to the vessel and yawing moments), the strength of the wind assisted propulsion system, the forces at the embedment and the list of the ship conform with the structural design file and the stability file of the ship, respectively. Where the lateral forces and yawing moment are particularly significant, the verifier may request course keeping and rudder angle demonstrations to validate conformity with the operational domain.

2.5 The global wind probability matrix W_k

2.5.1 Wind probabilities

2.5.1.1 Wind conditions are not constant. Winds vary their speed and direction with time. Wind expectations are unequal in different regions of the earth.

2.5.1.2 However, every wind expectation can be expressed in a distinctive wind probability pattern for every particular position on the globe. There is always a certain probability for a certain wind direction and wind speed to occur. These probabilities are documented in wind charts. With this approach each geographical region has a distinctive wind chart.

2.5.2 Wind angles relative to the ship

2.5.2.1 For a wind assisted propulsion system, it is irrelevant if the wind is coming from North or South. Only the wind angle relative to a ship's heading is of importance. As a consequence, the wind directions given in the weather data have to be recalculated for ship headings on a trading route when applied to wind assisted propulsion systems, where 0° means the ship's bow, 90° its starboard side, 180° the stern and 270° port side.

2.5.3 Main global shipping network

2.5.3.1 To determine a global wind probability chart for the wind assisted propulsion system's EEDI calculation, the average of all wind conditions along the main global shipping routes is required.

2.5.3.2 Figure 1 shows the main global shipping network used to determine the global wind conditions. Along the shown routes, 106 wind condition charts were analysed. These charts are based on 868,500 individual wind data.

2.5.3.3 The wind condition charts for each position were first recalculated in ship heading coordinates and then averaged to form a global wind condition chart. The results are visualized in figure 2, the complete chart (the global wind probability matrix) is shown as the table in appendix 2 of this annex.

2.5.3.4 Each element of the matrix W_k represents the probability of the specific wind speed and wind angle relative to the ship. The sum of all matrix elements is one (1.0), representing 100% of all wind conditions.

2.5.3.5 The results show that winds to the bow or the stern occur more often than winds to the sides. There are two possible reasons to explain this phenomenon:

.1 shipping routes and global weather systems are more East-West than North-South oriented; and

.2 shipping routes and winds are influenced by shore lines, so they tend to be parallel in some regions.

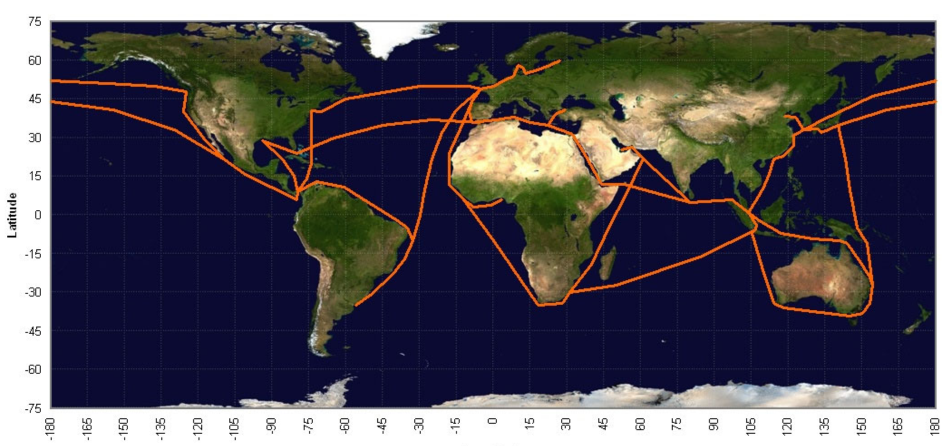

Figure 1 – The main global shipping network used for the wind chart

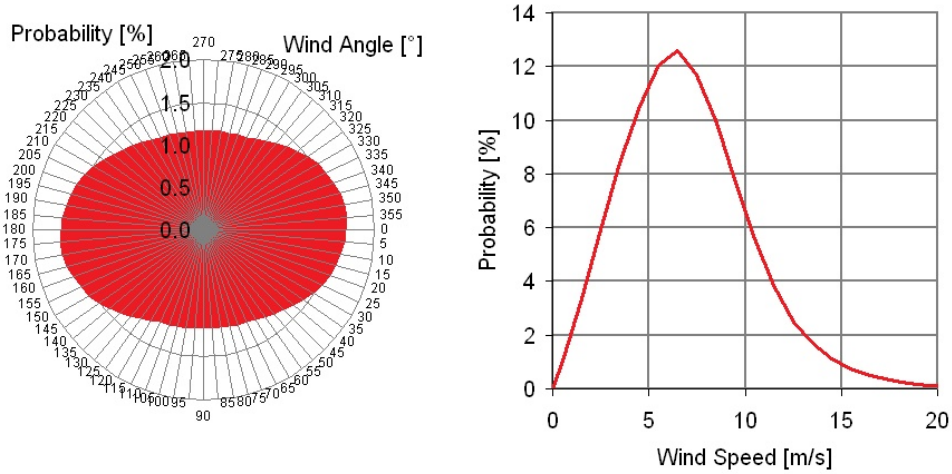

Figure 2 – Resulting wind curves on the main global shipping routes relative to the ship

2.6 Effective CO_2 reduction by wind assisted propulsion systems

2.6.1 For the calculation of the CO_2 reduction, the resulting available effective power (f_{eff} * P_{eff}) has to be multiplied with the conversion factor C_{FME} and SFC_{ME} , as contained in the original EEDI formula.

2.7 Verification of wind assisted propulsion systems in the EEDI certification process

2.7.1 General

2.7.1.1 Verification of EEDI with innovative energy efficient technologies should be conducted according to the EEDI Survey Guidelines. Additional items concerning innovative energy efficient technologies not contained in EEDI Survey Guidelines are described below.

2.7.2 Preliminary verification at the design stage

2.7.2.1 In addition to paragraph 4.2.2 of EEDI Survey Guidelines, the EEDI Technical File which is to be developed by the shipowner or shipbuilder should include:

.1 Outline of wind assisted propulsion systems; and

.2 Calculated value of EEDI due to the wind assisted propulsion system.

2.7.2.2 In addition to paragraph 4.2.7 of the EEDI Survey Guidelines, additional information from the shipbuilder may be requested by the verifier. It includes:

.1 Detailed calculation process of the wind propulsion system force matrix $F(V_{ref})_k$ and results of performance tests.

2.7.2.3 In order to prevent undesirable effects on the ship's structure or main drive, the influences of added forces on the ship should be determined during the EEDI certification process. Elements in the wind propulsion system force matrix may be limited to ship specific restrictions, if necessary. The technical means to restrict the wind propulsion system's force should be verified as part of the performance test.

2.7.2.4 If more than one innovative energy efficient technology is subject to approval in the EEDI certification, interactions between these technologies should be considered. The appropriate technical papers should be included in the additional information submitted to the verifier in the certification process.

2.7.3 Final verification of the attained EEDI

2.7.3.1 The total net power generated by wind assisted propulsion systems should be confirmed based on the documentation in the EEDI Technical File. For final verification, EEDI verifier should check that the configuration of the installed wind assisted propulsion system agrees with the system as described in the EEDI Technical File.

APPENDIX 1

METHOD OF WIND TUNNEL MODEL TEST

In accordance with section 2.4.1 of the present circular, two test methods are defined:

.1 option 1: test on a ship model fitted with the full wind assisted propulsion system; and

.2 option 2: test on a complete model of a single wind propulsion unit.

Option 1: Test on a ship model fitted with the full wind assisted propulsion system

1 Model

1.1 The wind assisted propulsion system model and the hull model should be made similarly to the real form, but appendages which do not affect the aerodynamic characteristics can be omitted from the model (e.g. handrails, windlass, etc.).

1.2 The draught condition of the hull model should be corresponding to the *Capacity* as defined in EEDI Calculation Guidelines.

1.3 The hull model is connected with the turntable by force balance, and the wind direction angle of the ship model is changed by changing the angle of the turntable.

2 Test condition

2.1 In addition to geometric similarity, the dynamic similarity criterion must be satisfied in the wind matrix wind tunnel model test of a ship's wind assisted propulsion system. That is, when the test wind speed is higher than a certain critical wind speed, the dimensionless wind coefficient tends to be stable, and the flow around the model is similar to the real ship. The measured wind coefficient can be directly extrapolated to the real ship. During the test, the critical wind speed is determined by a variable wind speed test.

2.2 In the wind tunnel model test, spires and roughness elements are arranged at the front of the test section, and the wind field of the atmospheric boundary layer on the ocean surface at the model scale for wind matrix test is obtained. Reynolds number of the test should be more than 1.0 x 10^6. The Reynolds number, *Re*, is expressed by the following formula:

$$\mu$$

where ρ and μ are the density and viscosity of the air, respectively, U is the wind speed, L_{pp} is the length between perpendiculars of the model ship.

2.3 The blockage ratio should not be more than 5%. The ratio is calculated by the transverse projected area of the model divided by the cross-sectional area of wind tunnel.

3 Test method

3.1 At the same hull wind direction, the wind propulsion coefficients of the wind assisted propulsion system are different at different angles of attack. In order to obtain the maximum wind propulsion coefficients of the wind assisted propulsion system at each hull wind direction angle, the test scheme should include:

.1 measurements of the aerodynamic force characteristics of the ship model without wind assisted propulsion system at a series of wind angles ranging from 0° to 360°, spaced by an interval of 5°, potentially extended to 10° only for beam to stern;

.2 measurements of the aerodynamic force characteristics of the ship model with wind assisted propulsion system at a series of wind angles ranging from 0° to 360°, spaced by an interval of 5° or 10°, attack angles of the wind assisted propulsion system range from 0° to 180°, spaced by an interval of 5° or 10° in every wind angle of the ship model. Smaller intervals of attack angles should be needed around the maximum wind propulsion coefficients; and

.3 in the case where the measurements are carried out with spaced by an interval of 10°, each intermediate force characteristic (i.e. F_X at 5°, 15°, 25°…) should be interpolated by using the measurement results.

3.2 In the case where the shape of the ship and wind assisted propulsion system are symmetrical on starboard side and port side, the wind propulsion coefficients are also symmetrical and thus, the measurements at a series of wind angles ranging from 0° to 180° or 180° to 360° can be omitted.

3.3 If the wind assisted propulsion system has a changeable and controllable structure, such as sails and rotors, the model of the wind assisted propulsion system can be arranged as the wind angle, the rotor speed, or other controllable structure to maximize the gained wind force or to minimize the wind resistance.

Option 2: Test on a complete model of a single wind propulsion unit

4 Model

4.1 The effects of the hull and superstructures should be taken into account by corrective actions taking into account the masked area and distance. If several wind propulsion units are installed on board the ship, the aerodynamic interactions between them should be taken into account by corrective actions. The verifier may request documentation from the test author to verify that these effects have been taken into account.

4.2 The wind propulsion unit model is connected to the turntable by means of a force balance, and the wind direction angle of the ship model is changed by changing the angle of the turntable.

5 Test conditions

5.1 In addition to geometric similarity, the dynamic similarity criterion must be satisfied in the wind matrix wind tunnel model test of a ship's wind assisted propulsion system. That is, when the test wind speed is higher than a certain critical wind speed, the dimensionless wind coefficient tends to be stable, and the flow around the model is similar to the real ship. The measured wind coefficient can be directly extrapolated to the real ship. During the test, the critical wind speed is determined by a variable wind speed test.

5.2 The maximum Reynolds number of the test should be more than 5.0×10^5. The Reynolds number, Re, is expressed by the following formula:

$$Re = \rho \, . \, U \, . \, C / \mu$$

where ρ and μ are the density and viscosity of the air, respectively, U is the wind speed, C is the mean chord length of the wind propulsion unit.

5.3 The blockage ratio should not be more than 5%. The ratio is calculated by the transverse projected area of the model divided by the cross-sectional area of wind tunnel.

6 Test method

6.1 In order to obtain the maximum wind propulsion coefficients of the wind assisted propulsion system at each ship wind direction angle, the test scheme should include measurements of the aerodynamic force characteristics for:

.1 a range of permissible angles of attack on the wind propulsion unit; and

.2 a range of permissible settings (profile camber, rotation speed, suction rate, reduced area, etc.).

6.2 The propulsive force on the ship is the aerodynamic force measured on the wind propulsion unit pointing to the bow.

APPENDIX 2

GLOBAL WIND PROBABILITY MATRIX W_k

Table 1 – Normalized global wind chart showing the probability of wind conditions relative to the ship's heading along the main global trading routes

Wind Angle [°] / Wind Speed [m/s]	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
<1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
<3	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
<4	0.0013	0.0013	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0010	0.0010	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011
<5	0.0017	0.0017	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014	0.0014	0.0013	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
<6	0.0021	0.0020	0.0020	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015
<7	0.0022	0.0022	0.0021	0.0020	0.0020	0.0019	0.0018	0.0017	0.0017	0.0016	0.0015	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015
<8	0.0020	0.0020	0.0020	0.0019	0.0019	0.0018	0.0017	0.0016	0.0016	0.0015	0.0014	0.0014	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0014	0.0014	0.0014
<9	0.0017	0.0017	0.0017	0.0016	0.0016	0.0016	0.0015	0.0014	0.0014	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012
<10	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0010	0.0010	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0009	0.0009
<11	0.0010	0.0010	0.0010	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
<12	0.0007	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
<13	0.0004	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002
<14	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
<15	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<18	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>=25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Angle [°] / Wind Speed [m/s]	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
<1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
<3	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
<4	0.0011	0.0011	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0012	0.0012	0.0012	0.0012	0.0011	0.0011	0.0011	0.0011
<5	0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0016	0.0016	0.0015	0.0015	0.0015	0.0014	0.0014	0.0013	0.0013
<6	0.0015	0.0016	0.0017	0.0017	0.0018	0.0019	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021	0.0021	0.0020	0.0020	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014
<7	0.0016	0.0016	0.0017	0.0018	0.0019	0.0020	0.0021	0.0021	0.0022	0.0022	0.0023	0.0022	0.0022	0.0022	0.0021	0.0020	0.0020	0.0019	0.0018	0.0017	0.0017	0.0016	0.0015	0.0014
<8	0.0015	0.0015	0.0016	0.0017	0.0017	0.0018	0.0019	0.0020	0.0020	0.0021	0.0021	0.0021	0.0020	0.0020	0.0020	0.0019	0.0019	0.0018	0.0017	0.0016	0.0016	0.0015	0.0014	0.0014
<9	0.0012	0.0012	0.0013	0.0014	0.0014	0.0015	0.0016	0.0016	0.0016	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0016	0.0016	0.0016	0.0015	0.0014	0.0014	0.0013	0.0013	0.0012
<10	0.0009	0.0009	0.0010	0.0010	0.0011	0.0011	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0010	0.0010
<11	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010	0.0010	0.0010	0.0010	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008
<12	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005
<13	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
<14	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002
<15	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
<16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
<19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>=25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Wind Angle [°] / Wind Speed [m/s]	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355
<1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<2	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
<3	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
<4	0.0011	0.0011	0.0011	0.0010	0.0010	0.0010	0.0010	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
<5	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0014	0.0014	0.0015	0.0015	0.0016	0.0016	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
<6	0.0014	0.0014	0.0014	0.0013	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015	0.0015	0.0016	0.0017	0.0017	0.0018	0.0019	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021
<7	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015	0.0015	0.0015	0.0015	0.0016	0.0016	0.0017	0.0018	0.0019	0.0020	0.0021	0.0021	0.0022	0.0022	0.0023	0.0022
<8	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0014	0.0014	0.0014	0.0015	0.0015	0.0016	0.0017	0.0017	0.0018	0.0019	0.0020	0.0020	0.0021	0.0021	0.0021
<9	0.0012	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012	0.0013	0.0014	0.0014	0.0015	0.0016	0.0016	0.0016	0.0017	0.0017	0.0017
<10	0.0010	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0010	0.0010	0.0011	0.0011	0.0012	0.0012	0.0012	0.0013	0.0013	0.0013
<11	0.0008	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0009	0.0009	0.0009	0.0010
<12	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0006	0.0006	0.0006	0.0007
<13	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
<14	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003
<15	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
<16	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<17	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
<18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
<19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
<25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
>=25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

ANNEX 2[6]

GUIDANCE ON CALCULATION AND VERIFICATION OF EFFECTS OF CATEGORY (C) INNOVATIVE TECHNOLOGIES

1 WASTE HEAT RECOVERY SYSTEM FOR GENERATION OF ELECTRICITY (CATEGORY (C-1))

1.1 Summary of innovative energy efficient technology

1.1.1 This chapter provides the guidance on the treatment of high temperature waste heat recovery systems (electric generation type) as innovative energy efficiency technologies related to the reduction of the auxiliary power (concerning $P_{AEeff(i)}$). Mechanical recovered waste energy directly coupled to shafts need not be measured in this category, since the effect of the technology is directly reflected in the V_{ref}.

1.1.2 Waste heat energy technologies increase the efficiency utilization of the energy generated from fuel combustion in the engine through recovery of the thermal energy of exhaust gas, cooling water, etc. thereby generating electricity.

1.1.3 There are the following two methods of generating electricity by the waste heat energy technologies (electric generation type):

.1 (A) method to recover thermal energy by a heat exchanger and to drive the thermal engine which drives an electric generator; and

.2 (B) method to drive directly an electric generator using power turbine, etc. Furthermore, there is a waste heat recovery system which combines both of the above methods.

[6] All examples in this chapter are used solely to illustrate the proposed methods of calculation and verification.

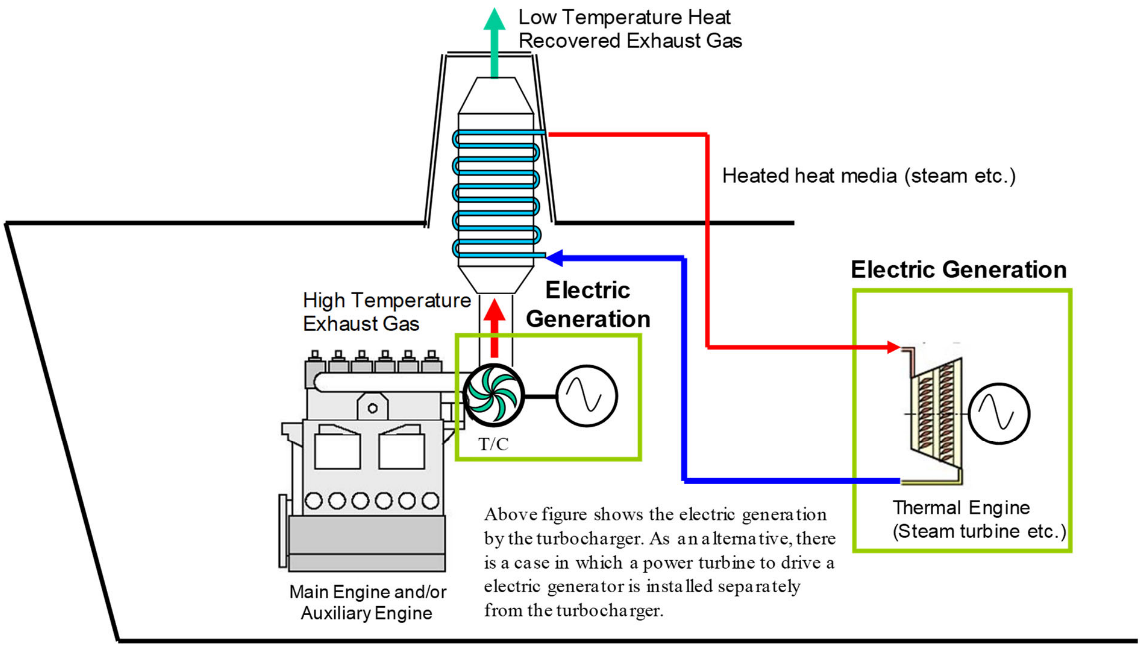

Figure 1 – Schematic illustration of Exhaust Heat Recovery

1.2 Method of calculation

1.2.1 Power reduction due to waste heating recovery system

1.2.1.1 The reduction of power by the waste heat recovery system is calculated by the following equation. For this system, f_{eff} is 1.00 in EEDI formula.

$$P_{AEeff} = P'_{AEeff} - P_{AEeff\_loss} \qquad (1)$$

In the above equation, P'_{AEeff} is power produced by the waste heat recovery system. P_{AEeff_Loss} is the necessary power to drive the waste heat recovery system.

1.2.1.2 P_{AEeff} is the reduction of the ship's total auxiliary power (kW) by the waste heat recovery system under the ship performance condition applied for EEDI calculation. The power generated by the system under this condition and fed into the main switch board is to be taken into account, regardless of its application on board the vessel (except for power consumed by machinery as described in paragraph 1.2.1.4 of this chapter).

1.2.1.3 P'_{AEeff} is defined by the following equation.

$$P'_{AEeff} = \frac{W_e}{\eta_g}, \qquad (2)$$

where:

W_e : Calculated production of electricity by the waste heat recovery system
η_g : Weighted average generator efficiency

1.2.1.4 P_{AEeff} is determined by the following factors:

.1 temperature and mass flow of exhaust gas of the engines, etc.;

.2 constitution of the waste heat recovery system; and

.3 efficiency and performances of the components of the waste heat recovery system.

1.2.1.5 P_{AEeff_Loss} is the power (kW) for the pump, etc. necessary to drive the waste heat recovery system.

1.3 Method of verification

1.3.1 General

1.3.1.1 Verification of EEDI with innovative energy efficient technologies should be conducted according to the EEDI Survey Guidelines. Additional items concerning innovative energy efficient technologies not contained in EEDI Survey Guidelines are described below.

1.3.2 Preliminary verification at the design stage

1.3.2.1 In addition to paragraph 4.2.2 of EEDI Survey Guidelines, the EEDI Technical File which is to be developed by the shipowner or shipbuilder should include:

.1 diagrams, such as a plant diagram, a process flow diagram, or a piping and instrumentation diagram outlining the waste heat recovery system, and its related information such as specifications of the system components;

.2 deduction of the saved energy from the auxiliary engine power by the waste heat recovery system; and

.3 calculation result of EEDI.

1.3.2.2 In addition to paragraph 4.2.7 of the EEDI Survey Guidelines, additional information that the verifier may request the shipbuilder to provide directly to it includes:

.1 exhaust gas data for the main engine at 75% MCR (and/or the auxiliary engine at the measurement condition of SFC) at different ambient air inlet temperatures, e.g. 5°C, 25°C and 35°C; which consist of:

  .1 exhaust gas mass flow for turbo charger (kg/h);

  .2 exhaust gas temperatures after turbo charger (C°);

  .3 exhaust gas bypass mass flow available for power turbine, if any (kg/h);

  .4 exhaust gas temperature for bypass flow (C°); and

  .5 exhaust gas pressure for bypass flow (bar).

.2 in the case of system using heat exchanger, expected output steam flows and steam temperatures for the exchanger, based on the exhaust gas data from the main engine;

.3 estimation process of the heat energy recovered by the waste heat recovery system; and

.4 further details of the calculation method of P_{AEeff} defined in paragraph 1.2.1 of this chapter.

1.3.3 Final verification of the attained EEDI at sea trial

1.3.3.1 Deduction of the saved energy from the auxiliary engine power by the waste heat recovery system should be verified by the results of shop tests of the waste heat recovery system's principal components and, where possible, at sea trials.

1.3.3.2 In the case of systems for which shop tests are difficult to be conducted, e.g. in case of the exhaust gas economizer, the performance of the waste heat recovery system should be verified by measuring the amount of the generated steam, its temperature, etc. at the sea trial. In that case, the measured vapour amount, temperature, etc. should be corrected to the value under the exhaust gas condition when they were designed, and at the measurement conditions of *SFC* of the main/auxiliary engine(s). The exhaust gas condition should be corrected based on the atmospheric temperature in the engine-room (Measurement condition of *SFC* of main/auxiliary engine(s); i.e. 25°C), etc.

2 PHOTOVOLTAIC POWER GENERATION SYSTEM (CATEGORY (C-2))

2.1 Summary of innovative energy efficient technology

2.1.1 Photovoltaic (PV) power generation system set on a ship will provide part of the electric power either for propelling the ship or for use inboard. PV power generation system consists of PV modules and other electric equipment. Figure 1 shows a schematic diagram of PV power generation system. The PV module consists of combining solar cells and there are some types of solar cell such as "Crystalline silicon terrestrial photovoltaic" and "Thin-film terrestrial photovoltaic", etc.

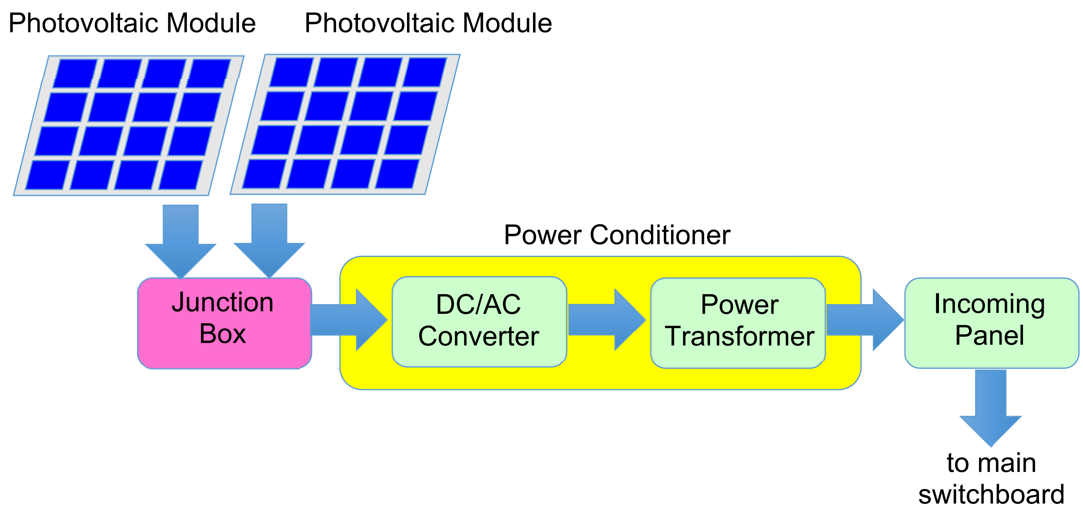

Figure 1 – Schematic diagram of photovoltaic power generation system

2.2 Method of calculation

2.2.1 Electric power due to photovoltaic power generation system

2.2.1.1 The auxiliary power reduction due to the PV power generation system can be calculated as follows:

$$f_{eff} \cdot P_{AEeff} = \{f_{rad} \times (1 + L_{temp} / 100)\} \times \{P_{max} \times (1 - L_{others} / 100) \times N / \eta_{GEN}\} \quad (1)$$

where $f_{eff} \cdot P_{AEeff}$ is the total net electric power (kW) generated by the PV power generation system.

2.2.1.2 Effective coefficient f_{eff} is the ratio of average PV power generation in main global shipping routes to the nominal PV power generation specified by the manufacturer. Effective coefficient can be calculated by the following formula using the solar irradiance and air temperature of main global shipping routes:

$$f_{eff} = f_{rad} \times (1 + L_{temp} / 100) \quad (2)$$

2.2.1.3 f_{rad} is the ratio of the average solar irradiance on main global shipping route to the nominal solar irradiance specified by the manufacturer. Nominal maximum generating power P_{max} is measured under the Standard Test Condition (STC) of IEC standard.[7] STC specified by manufacturer is that: Air Mass (AM) 1.5, the module's temperature is 25°C, and the solar irradiance is 1000 W/m^2. The average solar irradiance on main global shipping route is 200 W/m^2. Therefore, f_{rad} is calculated by the following formula:

$$f_{rad} = 200 \text{ W/m}^2 \div 1000 \text{ W/m}^2 = 0.2 \quad (3)$$

2.2.1.4 L_{temp} is the correction factor, which is usually in minus, and derived from the temperature of PV modules, and the value is expressed in per cent. The average temperature of the modules is deemed 40°C, based on the average air temperature on main global shipping routes. Therefore, L_{temp} is derived from the temperature coefficient f_{temp} (percent/K) specified by the manufacturer (see IEC standard[7]) as follows:

$$L_{temp} = f_{temp} \times (40°\text{C} - 25°\text{C}) \quad (4)$$

2.2.1.5 P_{AEeff} is the generated PV power divided by the weighted average efficiency of the generator(s) under the condition specified by the manufacturer and expressed as follows:

$$P_{AEeff} = P_{max} \times (1 - L_{others} / 100) \times N / \eta_{GEN}, \quad (5)$$

where η_{GEN} is the weighted average efficiency of the generator(s).

2.2.1.6 P_{max} is the nominal maximum generated PV power generation of a module expressed in kilowatt, specified based on IEC Standards.[7]

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7 Refer to IEC 61215 "Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval" for Crystalline silicon terrestrial PV modules, and to IEC 61646 "Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval" for Thin-film terrestrial PV modules.

2.2.1.7 L_{others} is the summation of other losses expressed by percent and includes the losses in a power conditioner, at contact, by electrical resistance, etc. Based on experiences, it is estimated that L_{others} is 10% (the loss in the power conditioner: 5% and the sum of other losses: 5%). However, for the loss in the power conditioner, it is practical to apply the value specified based on IEC Standards.[8]

2.2.1.8 *N* is the numbers of modules used in a PV power generation system.

2.3 Method of verification

2.3.1 General

2.3.1.1 Verification of EEDI with innovative energy efficient technologies is conducted according to EEDI Survey Guidelines**.** This section provides additional requirements related to innovative technologies.

2.3.2 Preliminary verification at the design stage

2.3.2.1 In addition to paragraph 4.2.2 of EEDI Survey guidelines, the EEDI Technical File which is to be developed by the shipowner or shipbuilder should include:

.1 outline of the PV power generation system;

.2 power generated by the PV power generation system; and

.3 calculated value of EEDI due to the PV power generation system.

2.3.2.2 In addition to paragraph 4.2.7 of the EEDI survey guidelines, additional information that the verifier may request the shipbuilder to provide directly to it includes:

.1 detailed calculation process of the auxiliary power reduction by the PV power generation system; and

.2 detailed calculation process of the total net electric power ($f_{eff} \cdot P_{AEeff}$) specified in section 2.2 in this guidance.

2.3.3 Final verification of the attained EEDI at sea trial

2.3.3.1 The total net electric power generated by PV power generation system should be confirmed based on the EEDI Technical File. In addition to the confirmation, it should be confirmed whether the configuration of the PV power generation systems on ship is as applied, prior to the final verification.

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8 IEC 61683 "Photovoltaic systems – Power conditioners – Procedure for measuring efficiency".

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BWM.2/Circ.66/Rev.2
13 December 2021

INTERNATIONAL CONVENTION FOR THE CONTROL AND MANAGEMENT OF SHIPS' BALLAST WATER AND SEDIMENTS, 2004

Unified interpretations to the BWM Convention

1 The Marine Environment Protection Committee, at its seventy-seventh session (22 to 26 November 2021), approved a unified interpretation to regulations E-1.1.1 and E-1.1.5 of the BWM Convention concerning the clarification of the date to be used for determining the implementation of mandatory commissioning testing of individual ballast water management systems.

2 The updated consolidated text of all existing unified interpretations to the BWM Convention, including that set out in BWM.2/Circ.66/Rev.1, is set out in the annex.

3 Member Governments and international organizations are invited to apply the annexed unified interpretations to the BWM Convention and bring them to the attention of all parties concerned.

4 This circular revokes BWM.2/Circ.66/Rev.1.

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ANNEX

UNIFIED INTERPRETATIONS TO THE BWM CONVENTION

1 Date to be used for determining the implementation of mandatory commissioning testing of individual ballast water management systems in accordance with resolution MEPC.325(75)

Regulation E-1
Surveys

Regulations E-1.1.1 and E-1.1.5 read as follows:

> "1 An initial survey before the ship is put in service or before the Certificate required under regulation E-2 or E-3 is issued for the first time. This survey shall verify that the ballast water management plan required by regulation B-1 and any associated structure, equipment, systems, fittings, arrangements and material or processes comply fully with the requirements of this Convention. This survey shall confirm that a commissioning test has been conducted to validate the installation of any ballast water management system by demonstrating that its mechanical, physical, chemical and biological processes are working properly, taking into account the guidelines developed by the Organization*.
>
> 5 An additional survey, either general or partial, according to the circumstances, shall be made after a change, replacement, or significant repair of the structure, equipment, systems, fittings, arrangements and material necessary to achieve full compliance with this Convention. The survey shall be such as to ensure that any such change, replacement or significant repair has been effectively made, so that the ship complies with the requirements of this Convention. When an additional survey is undertaken for the installation of any ballast water management system, this survey shall confirm that a commissioning test has been conducted to validate the installation of the system by demonstrating that its mechanical, physical, chemical and biological processes are working properly, taking into account the guidelines developed by the Organization*.
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> __________
> * Refer to the *2020 Guidance for the commissioning testing of ballast water management systems* (BWM.2/Circ.70/Rev.1), as amended."

Interpretation:

1.1 Irrespective of new ships under construction subject to regulation E-1.1.1 or existing ships retrofitting ballast water management system(s) (BWMS) on board subject to regulation E-1.1.5, the commissioning testing of individual BWMS taking into account the guidelines developed by the Organization* should be conducted if the initial or additional survey is completed on or after 1 June 2022. If the initial or additional survey is completed before 1 June 2022, the commissioning testing of individual BWMS remains subject to the specific requirements of the Administration(s).

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* Refer to the *2020 Guidance for the commissioning testing of ballast water management systems* (BWM.2/Circ.70/Rev.1), as amended.

2 "Date installed" in relation to "Method of ballast water management used"

Appendix I
Form of the International Ballast Water Management Certificate

The following information regarding "Details of ballast water management method(s) used" is to be provided on the certificate:

"Method of ballast water management used ………………………………

Date installed (if applicable) ....

Name of manufacturer (if applicable) ...."

Interpretation:

2.1 For the purpose of completing the International Ballast Water Management Certificate, the date when commissioning has been completed in accordance with section 8 of the BWMS Code (resolution MEPC.300(72)) should be used.

2.2 Notwithstanding the above, it should be noted that, with regard to the deadline for installing a ballast water management system, operative paragraph 5 of resolution MEPC.300(72) (*Code for Approval of Ballast Water Management Systems*) is as follows:

> "5 RESOLVES that, for the purpose of operative paragraph 4 of this resolution, the word "installed" means the contractual date of delivery of the ballast water management system to the ship. In the absence of such a date, the word "installed" means the actual date of delivery of the ballast water management system to the ship;"

2.3 Consequently, two dates, i.e. the contractual date of delivery or the actual date of delivery, and the date following commissioning and operation, may exist in relation to installing a ballast water management system.

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