GUIDELINES FOR TESTING AND SURVEY OF EXHAUST GAS CLEANING SYSTEMS

2022

Effective from 1 December 2022

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Preface

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 Annex VI, including the standards on fuel oil sulphur content set forth in regulation 14. As an alternative compliance method, Guidelines for Exhaust Gas Cleaning Systems have been developed by IMO to provide standards for survey and testing for compliance of emissions from exhaust gas cleaning system.

In accordance with the IMO 2021 Guidelines for Exhaust Gas Cleaning Systems (MEPC.340 (77)), IS Classhas formulated ISC Guidelines for Testing and Survey of Exhaust Gas Cleaning Systems (hereinafter referred to as the "Guidelines") for the testing, survey, certification and approval of Exhaust Gas Cleaning Systems (EGCS).

Table 1 provides the emission ratio limit values corresponding to the fuel oil sulfur content specified in Regulations 14.1 and 14.4 of MARPOL Annex VI, which serves as the basis for verifying that the emissions from the EGCS are equivalent to the relevant provisions in Regulation 14 of MARPOL Annex VI using these Guidelines. 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 MARPOL Annex VI, they should be subject to special consideration by ISC.

Emission ratio limit values corresponding to fuel oil sulfur content Table 1

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.	

Chapter 1 General

1.1 Application and purpose

1.1.1 The Guidelines apply to the exhaust gas cleaning systems (hereinafter referred to as EGC system) subject to surveys by IS Class(hereinafter referred to as ISC) upon the authorization by the Administration or upon the request by clients. The Guidelines may also serve as references for marine product manufacturers, shipyards or shipowners to carry out testing of EGC units at test bed or onboard ships.

1.1.2 The Guidelines are developed based on 2021 Guidelines for Exhaust Gas Cleaning Systems, (Resolution MEPC.340(77)).

1.1.3 The Guidelines specify the standards for testing, survey, certification and compliance verification of EGC systems, to ensure that the EGC systems, as the alternatives for emission compliance specified in regulation 4 of MARPOL Annex VI, 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 and/or 14.4 of MARPOL Annex VI, as applicable.

1.2 General requirements

1.2.1 The Guidelines describe two schemes for approval of an EGC system: 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 EGC system is subject to approval by ISC and is to be subject to performance tests, sea trials or other similar physical tests as specified in Chapter 3 of the Guidelines 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 EGC system is subject to approval by ISC and is to be in compliance with the provisions in Chapter 4 of the Guidelines. Approved exhaust gas monitoring system should continuously indicate the Emission Ratio while the EGC system is in operation, allowing verification against the applicable limit.

1.2.2 Emission testing in relation to either Scheme A or Scheme B is to be undertaken, as appropriate, in compliance with the requirements of 5.1 of Chapter 5 of the Guidelines.

1.2.3 Data recording, retention and the preparation of reports using that data in relation to either Scheme A or Scheme B are to be, as appropriate, in compliance with the applicable requirements of 5.2 of Chapter 5 of the Guidelines.

1.2.4 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 are to be documented, as appropriate, in accordance with the applicable requirements of Chapter 6 of the Guidelines.

1.2.5 For ships which are to use an EGC system 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 SOX Emissions Compliance Plan (SECP). The SECP is to be in compliance with the requirements of Chapter 7 of the Guidelines.

1.2.6 Discharge water monitoring which is equally applicable to Scheme A and Scheme B is to be undertaken in compliance with the requirements of Chapter 8 of the Guidelines.

1.2.7 The discharge outlet of the discharge water used in the EGC system is to be located as far from the ship's seawater inlet as possible. 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 due to corrosion, due care is to 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.

1.2.8 Sampling positions of ECG systems and permanent access platforms are to be such that this monitoring may be performed safely.

1.2.9 When EGC systems are operated, tested and surveyed onboard, due attention is to be given to the safety implications related to the handling and proximity of high temperature exhaust gases, the measurement equipment and the storage and use of pressurized containers of calibration gases.

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

1.3 Application

1.3.1 The Guidelines apply to any EGC system as applied to fuel oil combustion unit(s), excluding shipboard incinerators, installed on board a ship.

1.3.2 For the purpose of these Guidelines, the term "EGCS" should be generally, except for 1.3.3, understood as "wet EGCS".

1.3.3 In the absence of specific guidelines for EGC systems which use technologies or operate in modes that are not defined in 1.4 of the Guidelines, the Guidelines may also be applied as appropriate.

1.3.4 These Guidelines apply to:

(1) EGC 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

(2) EGC 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 EGC system to the ship on or after 1 June 2022 or, in the absence of a contractual delivery date, the actual delivery of the EGC system to the ship on or after 1 June 2022; or

(3) amendments as those specified in 3.6.4 of Chapter 3 or 4.6.3 of Chapter 4 of the Guidelines to existing EGC systems undertaken on after 1 June 2022.

1.4 Definitions, abbreviations and symbols

1.4.1 Definitions

(1) **12-hour Period** means a period of 12 consecutive hours determined on a rolling basis with new 12-hour periods beginning past each hour of EGC system operation.

(2) **Bleed-off Water** means an amount of aqueous solution removed from the washwater of an EGC system operating in closed-loop mode to keep its required operating properties and efficiency.

(3) **Certified Value** means The Emission Ratio specified by the manufacturer that the EGC system 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.

(4) **Closed-loop Mode** means 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 EGC system residue.

(5) **Continuous Monitoring** means process and technology used for evaluation of EGC system compliance through representative measurement, at a specified frequency, for selected parameters.

(6) **Discharge Water** means any water from an EGC system to be discharged overboard.

(7) **EGC Unit** means 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.

(8) **EGCS Electronic Data Recording or Electronic Logging System** means automatic record of the EGCS in service operating parameters. The record of parameters does not involve any user input.

(9) **EGCS Record Book**(or Electronic Record Book)means a user-input record of the EGCS, component adjustments, corrective and planned maintenance and service records as appropriate. It can have an electronic format.

(10) **EGCS Residue** means 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.

(11) **Emission Ratio** means SO_2 expressed in ppm/CO_2 expressed in % v/v.

(12) **Exhaust Gas Cleaning System (EGCS)** means 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.

(13) **Extractive Sampling System** means system which extracts a sample flow from the exhaust gas stream and transfers it by heated lines to the measurement instrument.

(14) **Fuel Oil Combustion Unit** means any engine, boiler, gas turbine, or other fuel oil fired equipment, excluding shipboard incinerators.

(15) **Inlet Water** means water entering the ship as a cleaning medium for an EGC unit.

(16) **In Situ** means measuring directly within an exhaust gas stream.

(17) **Load Range** means interval ranging from minimum practicable to maximum rated power of diesel engine or maximum steaming rate of the boiler.

(18) **Open-loop Mode** means 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.

(19) **Phenanthrene Equivalent** 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.

(20) **Washwater** means cleaning medium brought into contact with the exhaust gas stream for the reduction of SO_X.

(21) **Wet EGCS** means EGCS using liquid cleaning medium.

1.4.2 Abbreviations

(1) CL: Closed-Loop.

(2) EGC: Exhaust Gas Cleaning.

(3) EGCS: Exhaust Gas Cleaning System.

(4) ETM-A: EGCS -Technical Manual for Scheme A.

(5) ETM-B: EGCS -Technical Manual for Scheme B.

(6) GNSS: Global Navigational Satellite System.

(7) MCR: Maximum Continuous Rating.

(8) SECP: SO_x Emissions Compliance Plan.

(9) SECC: SO_x Emissions Compliance Certificate.

(10) OL: Open-Loop.

(11) OMM: Onboard Monitoring Manual.

(12) PAH: Polycyclic Aromatic Hydrocarbons.

(13) PAH_{phe}: Polycyclic Aromatic Hydrocarbons as phenanthrene equivalents (see the definitions in 1.4.1(19) of the Guidelines).

(14) UTC: Universal Time Co-ordinated.

1.4.3 Symbols

(1) SO_x: Sulphur oxides.

(2) SO_2: Sulphur dioxide.

(3) CO_2: Carbon dioxide.

Chapter 2 Survey and Certification

2.1 General requirements

2.1.1 The Guidelines provide two schemes for the approval, survey and certification of EGC systems; Scheme A or Scheme B.

2.1.2 Product manufacturers or other parties applying for the use of Scheme A or Scheme B for survey certification of EGS systems are to comply with the relevant requirements of Chapter 3 or Chapter 4 of the Guidelines respectively.

2.2 Surveys

2.2.1 EGC systems are normally subject to surveys as follows:

(1) **SECC certification survey.** The EGC systems for which the application for the use of Scheme A is made are to be subject to SECC certification survey, in order to demonstrate by testing that emissions from EGC systems meet the certified value specified by the manufacturer under the operating conditions and restrictions as given by ETM-A. The certified value is at least to ensure that SO_x emissions from ships in operation are in compliance with the requirements given by MARPOL Annex VI regulations 14.1 and/or 14.4. Each EGC system upon a satisfactory survey is to be issued with the SO_x Emissions Compliance Certificate (SECC) by ISC. The form of the SECC is given in Appendix 1.

(2) **Installation and initial survey.** The EGC systems for which the application for the use of Scheme A or Scheme B is made are to be subject to installation and initial survey upon installation onboard and before being put into service, in order to confirm that for each EGC system certificates and relevant documents are complete, the EGC systems are installed in accordance with the requirements of ETM-A or ETM-B, and the performance of EGC systems in operation is in compliance with relevant requirements as demonstrated by the onboard verification procedures . This survey is to be taken as part of the initial survey of the ship and following a satisfactory survey, section 2.6 of the Supplement to the ship's International Air Pollution Prevention Certificate (IAPP) is to be duly completed.

(3) **In service surveys.** In service surveys as part of the ship surveys required in MARPOL Annex VI regulations 5 are such as to ensure compliance of emissions from EGC systems while the ship is in service. In service surveys include annual, intermediate and renewal surveys. The date of survey is to be based on the date of issuance of IAPP certificate after completion of initial certification survey.

2.3 Application for surveys

2.3.1 Application for the surveys outlined in 2.2 is to be made to ISC by EGC system manufacturers, shipyards or ship companies by means of a required form or a formal letter.

2.3.2 The applicant is to make all preparation and arrangements as necessary prior to the survey and provide active support according to relevant provisions of the Guidelines in order to ensure smooth proceeding of the work required by ISC. The applicant is to give an authentic description and introduction and provide relevant documents and is responsible for their authenticity.

2.3.3 The applicant is to, in accordance with the relevant requirements of the Guidelines, submit the application (form or letter) together with the relevant technical documents to ISC for review or approval.

2.4 Certificates

2.4.1 Following a satisfactory survey outlined in 2.2.1(1), the EGC system is to be issued with the SO_x Emissions Compliance Certificate (SECC).

2.4.2 Following a satisfactory survey outlined in 2.2.1(2) of the EGC system, section 2.6 of the Supplement to the ship's International Air Pollution Prevention Certificate (IAPP) is to be duly completed.

2.4.3 Following a satisfactory survey outlined in 2.2.1(3) of the EGC system, the ship's International Air Pollution Prevention Certificate (IAPP) is to be endorsed.

Chapter 3 EGC System Approval, Survey and Certification – Scheme A

3.1 General requirements

3.1.1 Where the use of Scheme A is applied for, EGC systems are to be approved, surveyed and certified according to the requirements of this Chapter.

3.1.2 Options for EGCS approval using Scheme A are as follows:

(1) individual EGCS approval;

(2) serially manufactured systems; and

(3) production range approval.

3.2 Plans and documents

3.2.1 The following documents and information are to be submitted for approval if Scheme A is applied for:

(1) SO_x Emissions Compliance Plan (SECP);

(2) EGC System-Technical Manual (ETM-A);

(3) Onboard Monitoring Manual (OMM);

(4) EGCS Record Book or Electronic Logging System;

(5) other documents and information as deemed necessary by ISC.

3.3 Approval of EGC systems

3.3.1 Individual EGCS is to be approved according to the following provisions:

(1) The EGCS is to be demonstrated by testing as capable of meeting the certified emission ratio value specified by the manufacturer. The certified value is at least to ensure that emissions from ships in operation are in compliance with the standards given by MARPOL Annex VI regulations 14.1 and/or 14.4. Testing is to be undertaken with fuel oils of the manufacturer's specified maximum % m/m sulphur content and the range of operating parameters are as listed in 3.6.1(2) of this Chapter.

(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 are to have a difference in % m/m sulphur content sufficient to demonstrate the operational behaviour of the EGCS and to demonstrate that the certified value specified in 3.3.1(1) 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 3.4 of this Chapter as appropriate, are to be performed. These tests need not be sequential and could be undertaken on two different, but identical, EGCSs.

(3) The maximum and, if applicable, minimum exhaust gas mass flow rate of the EGCS are to be stated. The effect of variation of the other parameters defined in 3.6.1(2) is to be justified by the equipment manufacturer. The effect of variations in these factors is to be assessed by testing or otherwise as appropriate. No variation in these factors, or combination of variations in these factors, is to be such that the emission value of the EGCS would be in excess of the certified value.

(4) Data obtained are be submitted to ISC for approval together with the ETM-A.

3.3.2 For serially manufactured EGC systems,in the case of nominally similar EGCSs of the same mass flow ratings as that certified under 3.3.1 above, the equipment manufacturer may submit a statement of conformity of production arrangement. Upon satisfactory verification by ISC that adequate arrangements have been made to ensure effective control of the conformity of production arrangement, the testing of each EGCS can be avoided. The certification of each EGCS under this arrangement is to be subject to such surveys that ISC may consider necessary as to assure that each certified EGCS has an emission ratio value of not more than the certified value when operated in accordance with the parameters defined in 3.6.1(2).

3.3.3 Product range approval is to comply with the following requirements:

(1) In the case of an EGCS of the same design, but of different maximum exhaust gas mass flow capacities, ISC may accept, in lieu of tests on an EGCS of all capacities, tests of EGCS 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.

(2) Where there are significant differences in the design of EGCS of different capacities, the procedure in (1) above is not to be applied unless it can be shown that in practice those differences do not materially alter the performance between the various EGCS types.

(3) For EGCS of different capacities, the sensitivity to variations in the type of combustion machinery to which they are fitted is to be detailed together with sensitivity to the variations in the parameters listed in 3.6.1(2). This is to be on the basis of testing, or other data as appropriate.

(4) The effect of changes of EGCS capacity on washwater and discharge water characteristics is to be detailed.

(5) All supporting data obtained, together with the ETM-A for each system, are to be submitted to ISC for approval.

3.4 Emission limits

3.4.1 Each EGCS is to 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 3.6.1(2) of the Guidelines.

3.4.2 In order to demonstrate performance of EGCSs, emission measurements are to be undertaken, with the agreement of the ISC, at a minimum of four load points. One load point is to be at 95% to 100% of the maximum exhaust gas mass flow rate for which the system is to be certified. One load point is to be within ± 5% of the minimum exhaust gas mass flow rate for which the system is to be certified. The other two load points are to 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 is to be increased so that it is demonstrated that the required performance over the stated exhaust gas mass flow rate range is retained. Additional intermediate load points are to be tested if there is evidence of an emission peak within the specified exhaust gas mass flow range. These additional tests are to be of sufficient number as to establish the emission peak value.

3.5 SECC Certification

3.5.1 Application for an SECC is to be made by the EGCS manufacturer, shipowner or other party.

3.5.2 In order to meet the requirements of 3.3 of this Chapter, either prior to, or after installation on board, each EGCS is to 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 ETM-A.

3.5.3 The certified value is to be determined according to the provisions of the Guidelines.

3.5.4 Each EGCS after being surveyed as meeting the requirements of 3.5.2 is to be issued with a SECC by ISC. The form of the SECC is given in Appendix 1 of the Guidelines.

3.5.5 Any subsequent EGCS of the same design and rating as that certified under 3.5.2 may be issued with an SECC without the need for testing in accordance with 3.5.2, subject to a satisfactory survey according to 3.3.2 of the Guidelines.

3.5.6 EGCSs of the same design, but with ratings different from that certified under 3.5.2 are to be subject to surveys and certification according to 3.3.3 of the Guidelines.

3.5.7 EGCSs which treat only part of the exhaust gas flow of the uptake in which they are fitted are to be subject to special consideration by ISC 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.

3.6 EGCS Technical Manual (ETM-A)

3.6.1 Each EGCS is to be supplied with an EGCS Technical Manual (ETM-A) provided by the manufacturer. This ETM-A is, as a minimum, to 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 related ancillary systems. In case a system contains more than one EGC unit, each EGC unit is to be identified;

(2) the operating limits, or range of operating values, for which the system is certified. These are, as a minimum, to 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 for which the EGCS is to be connected to. For boilers, the maximum air/fuel ratio at 100% load is also to be given. For diesel engines whether the engine is of 2 or 4-stroke cycle is to be indicated;

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

⑦ 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 requirement or restriction 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 are to 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 at surveys to ensure that the system's performance is maintained and that the system is used as required (see 3.7 of the Guidelines);

(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 6.2.1(8) of Chapter 6 of the Guidelines.

3.6.2 The ETM-A is to be approved by ISC.

3.6.3 The ETM-A is to be retained on board the ship onto which the EGCS is fitted and is to be available for surveys as required.

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

3.7 Onboard verification procedures

3.7.1 For each EGCS, the ETM-A is to contain a verification procedure for use at surveys as required. This procedure is not to require specialized equipment or an in-depth knowledge of the system. Where particular devices are required they are to be provided and maintained as part of the system. The EGCS is to be designed in such a way as to facilitate inspection as required. The basis of this 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.

3.7.2 All components and operating values or settings which may affect the operation and performance of the EGCS are to be detailed in the verification procedure.

3.7.3 The verification procedure is to be provided by the EGCS manufacturer and approved by ISC.

3.7.4 The verification procedure is to cover both a documentation check and a physical check of the EGCS.

3.7.5 The Surveyor is to verify that each EGCS is installed in accordance with the ETM-A and has an SECC as required.

3.7.6 During onboard survey, the Surveyor is to have the option of checking one or all of the identified components, operating values or settings as appropriate. Where there is more than one EGC unit within the EGCS, the Surveyor may, at his discretion, abbreviate or reduce the extent of the survey on board, however, the entire survey is to 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.

3.7.7 The EGCS is to include means to automatically record when the system is in use. The means is to automatically record, at least at the frequency specified in 4.5.2 of Chapter 4 of the Guidelines, as a minimum, washwater pressure and flow rate at the EGC unit's inlet connection, exhaust gas pressure before and pressure drop across the EGC unit, fuel oil combustion equipment 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 is to comply with the requirements of 5.2 of Chapter 5 and Chapter 6 of the Guidelines. In case of a system consuming chemicals at a known rate as documented in ETM-A, records of such consumption in the EGCS Record Book also serve this purpose.

3.7.8 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 is to be undertaken to verify compliance in conjunction with the continuous monitoring of the parameters stipulated in 3.7.7 above. The exhaust gas readings are to be allowed to stabilize before commencing recording. Readings from the calibration procedure are to be automatically recorded or noted in a calibration protocol. Emission values, which are used to determine the emission ratio, obtained after stabilization are to be recorded. If a continuous exhaust gas monitoring system is fitted, only daily spot checks of the parameters listed in 3.7.7 above would be needed to verify proper operation of the EGCS.

3.7.9 An EGCS Record Book is to be maintained on board the ship recording maintenance and service of the system including like-for-like replacement. The form of this record is to be submitted by the EGCS manufacturer and approved by ISC. This EGCS Record Book is to 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. Alternatively, this information may be recorded in the ship's planned maintenance record system as approved by ISC. Alternatively, this information may be recorded in an Electronic Record Book as approved by ISC. The EGCS Record Book entries are to be maintained on board the ship for a minimum period of three years after the last entry has been made.

Chapter 4 EGC System Approval, Survey and Certification – Scheme B

4.1 General requirements

4.1.1 Where the use of Scheme B is applied for, EGC systems are to be approved, surveyed and certified according to the requirements of this Chapter.

4.1.2 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.

4.2 Plans and documents

4.2.1 The following documents and information are to be submitted for approval if Scheme B is applied for:

(1) SO_x Emissions Compliance Plan (SECP);

(2) EGC System-Technical Manual (ETM-B);

(3) Onboard Monitoring Manual (OMM);

(4) EGCS Record Book or Electronic Logging System;

(5) other documents as deemed necessary by ISC.

4.3 Approval

4.3.1 The ETM-B, as defined in 4.6 of this Chapter, is to be approved by ISC.

4.4 Survey and certification

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

4.4.2 Following the satisfactory installation survey given in 4.4.1 above and approval of plans and documents as listed in 4.2.1, sections 2.3 and 2.6 of the Supplement to the ship's International Air Pollution Prevention Certificate is to be duly completed.

4.5 Exhaust gas monitoring

4.5.1 The exhaust gas composition of the emission ratio is to be measured at an appropriate position after the EGC unit and that measurement is to be as given in 5.1 of Chapter 5 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.

4.5.2 SO_2(ppm) and CO_2(%) and, to not less than one decimal place, the emission ratio are to be continuously monitored and recorded against the applicable emission ratio limit onto a data recording and processing device at a rate which is not to 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 are to, 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.

4.5.3 If more than one analyser is to be used to determine the emission ratio, these are to 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.

4.6 EGC System Technical Manual (ETM-B)

4.6.1 Each EGCS is to be supplied with an ETM-B provided by the Manufacturer. This ETM-B is, as a minimum, to 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 is to be identified;

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

① 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 is also to be given for diesel engines whether the engine is of 2 or 4-stroke cycle;

④ 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 6.2.1(8) of Chapter 6 of the Guidelines.

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

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

4.7 Onboard verification procedures

4.7.1 Daily spot checks of the parameters listed in 3.7.7 of Chapter 3 of the Guidelines are needed to verify proper operation of the EGCS and are to be recorded in the EGCS Record Book or in the engine-room logger system.

4.7.2 The data recording system is to comply with the requirements of 5.2 of Chapter 5 and Chapter 6 of the Guidelines. Data and the associated reports are to be available to ISC as necessary to demonstrate compliance as required.

4.7.3 An EGCS Record Book is to be maintained on board the ship recording maintenance and service of the system including like-for-like replacement. The form of this record book is to be submitted by the EGCS manufacturer and approved by the ISC. This EGCS Record Book is to 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. Alternatively, this information may be recorded in the ship's planned maintenance record system as approved by ISC. Alternatively, this information may be recorded in an Electronic Record Book as approved by ISC. The EGCS Record Book entries are to be maintained on board the ship for a minimum period of three years after the last entry has been made.

Chapter 5 Emission Testing, Data Recording and Processing Device

5.1 Emission testing

5.1.1 In addition to the requirements provided in the Guidelines, emission testing is to follow the requirements of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines.

5.1.2 CO_2 is to be measured using an analyser operating on non-dispersive infra-red (NDIR) principle and with additional equipment such as dryers as necessary. SO_2 is to be measured using analysers operating on non-dispersive infra-red (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 ISC, 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 is to be in accordance with the requirements of Appendix 7 of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines.

5.1.3 The analysing equipment is to 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 1.6 to 1.10 of Appendix 7 of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines are met at all times the equipment is in operation.

5.1.4 An exhaust gas sample for SO_2 is to be obtained from a representative sampling point downstream of the EGC unit.

5.1.5 SO_2 and CO_2 are to be sampled using either in situ or extractive sample systems.

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

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

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

5.1.9 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 are to be compared on a dry basis. If measured on a wet basis the water content in the exhaust gas stream at those points is also to 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 5.7.1.2(2) of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines.

5.1.10 Extractive sample systems are to be verified to be free of ingress leakage in accordance with the analysing equipment manufacturers' recommendations at intervals as defined in the OMM. It is to 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.

5.1.11 The span gases for the SO_2 and CO_2 analyser are to 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 is to conform to the requirements of Appendix 8 of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines. Other equivalent arrangements, as detailed in the OMM, may be accepted by ISC.

5.2 Data recording and processing device

5.2.1 Data recording and processing device are to comply with the requirements of ISC Guidelines for Type Approval Test of Electric and Electronic Products.

5.2.2 The data recording and processing device are to be of robust, tamper-proof design with read-only capability.

5.2.3 The recording and processing device is to record, whenever the EGCS is in operation, the data described in 3.7.7 of Chapter 3, 4.5.2 of Chapter 4, and 8.4 of Chapter 8 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 of MARPOL Annex VI at that time. The device is also to 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, 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.

5.2.4 The recording and processing device are to be capable of preparing reports over specified time periods.

5.2.5 Data is to 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 is to be ensured that the required data is retained on board and available as required for inspection.

5.2.6 The device is to be capable of downloading a copy of the recorded data and reports in a readily useable format. Such copy of the data and reports is to be available as requested during inspection.

Chapter 6 Onboard Monitoring Manual (OMM)

6.1 General requirements

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

6.2 OMM

6.2.1 The OMM is to, 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 is to be included are provided in Appendix 5 of the Guidelines;

(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 3.3.7 of Chapter 3 or 4.5.2 of Chapter 4;

(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 is therefore not to be considered as a breach of the requirements (see Appendix 6 of the Guidelines for details);

(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 is to 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 is to be considered part of the OMM.

6.2.2 The OMM is to 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.

6.2.3 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 is to describe the operational condition(s) which demonstrate the operational behaviour of the monitoring system and which is to be used when surveying in accordance with 4.4 of Chapter 4 of the Guidelines. 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.

6.2.4 The OMM is to be approved by ISC and retained on board the ship onto which the EGCS is installed and is to be available for surveys as required.

Chapter 7 Ship Compliance

7.1 SO_x Emissions Compliance Plan (SECP)

7.1.1 For all ships which are to use an EGCS to clean SO_x emissions, in part or in total, as an approved equivalent means to the requirements given by regulations 14.1 and 14.4 of MARPOL Annex VI there is to be a SO_x Emissions Compliance Plan (SECP) for the ship, approved by ISC.

7.1.2 The SECP is to list each fuel oil combustion unit which is to meet the requirements of regulations 14.1 and/or 14.4 of MARPOL Annex VI.

7.1.3 The SECP is to list each fuel oil combustion unit which may use Scheme A and/or B 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.

7.1.4 The SECP is to advise that records are to be kept of actions initiated to meet the requirement of the Guidelines in case of breakdown of the EGCS or associated equipment, and that relevant parties are to be notified in accordance with Appendix 6 of the Guidelines.

7.2 Demonstration of compliance

7.2.1 Where Scheme A is adopted in the EGCS, the following requirements are to be complied with:

(1) The SECP is to refer to, not reproduce, the ETM-A, EGCS Record Book or engine-room logger system, OMM, and other relevant documents as specified in Chapter 3 of the Guidelines.

(2) For all fuel oil combustion units listed under 7.1.2 of this Chapter, details are to be provided demonstrating that the rating and restrictions for the EGCS specified in 3.6.1(2) of Chapter 3 of the Guidelines are complied with.

(3) Required parameters are to be monitored and recorded as required under 3.7.7 of Chapter 3 of the Guidelines when the EGCS is in operation in order to demonstrate compliance.

7.2.2 The SECP is to refer to, not reproduce, the ETM-B, EGCS Record Book or engine-room logger system, OMM, and other relevant documents as specified in Chapter 4 of the Guidelines.

Chapter 8 Discharge Water

8.1 Discharge water quality criteria [①]

8.1.1 EGCS discharge water is to comply with the following criteria of 8.1.2 to 8.1.7 respectively prior to being discharged into the sea.

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

(1) The discharge water is to 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) approved by ISC, and in accordance with the following conditions to be recorded in the ETM-A or ETM-B:

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 use 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 are also to be evaluated to ensure that the overboard pH discharge limit is met under any load;

④ reference is to be made to a sea-water alkalinity of 2,200 μ mol/litre and pH 8.2 [②]; an amended titration curve is to be applied where the testing conditions differ from the reference seawater, as agreed by ISC (example titration curve for reference seawater conditions is presented in Appendix 4 of the Guidelines); and

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① The discharge water quality criteria may be revised 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 of the Guidelines.

② These values could be revised within two years for new installations following the adoption of 2021 Guidelines for Exhaust Gas Cleaning Systems by IMO upon further inputs on the physical state of the seas, reference sea-water alkalinity, and pH value resulting from the use of exhaust gas cleaning systems.

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

8.1.3 The discharge water PAH (Polycyclic Aromatic Hydrocarbons) is to comply with the following requirements. The appropriate limit is to be specified in the ETM-A or ETM-B.

(1) The maximum continuous PAH concentration in the discharge water is not to be greater than 50 μg/L PAHphe (phenanthrene equivalent) above the inlet water PAH concentration. For the purposes of this criteria, the PAH concentration in the discharge water is to 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.

(2) 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 or 80% of the power rating 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. The correspondence between the PAH limit and discharge water flow rates is given in Table 8.1.3. This limit would have to be adjusted upward for lower washwater flow rates (t/h) per MW, and vice versa, according to Table 8.1.3.

Discharge water PAH concentration limit **Table 8.1.3**

Discharge water flow rate (before dilution for pH control) (t/MWh)	PAH concentration limit (μg/L PAHphe equivalents)	Measurement technology
0 ~ 1	2250	Ultraviolet light*
2.5	900	Ultraviolet light*
5	450	Fluorescence ①
11.25	200	Fluorescence
22.5	100	Fluorescence
45	50	Fluorescence
90	25	Fluorescence
Note*: Alternative measurement technologies may be used with the agreement of ISC. Note ① :For any flow rate > 2.5 t/MWh, fluorescence technology is to be used.		

(3) For an aggregated 15-minute period in any 12-hour period, the continuous PAH concentration limit may exceed the limit described in Table 8.1.3 by up to 100%. This would allow for an abnormal start-up of the EGCS.

8.1.4 The discharge water turbidity/suspended particle matter is to comply with the following requirements:

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

(2) The maximum continuous turbidity in the discharge water is not to 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 are to be a rolling average over a maximum 15-minute period to a maximum of 25 FNU or NTU.

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

8.1.5 The content of nitrates in discharge water is to comply with the following requirements.

(1) The discharge water treatment system is to 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.

(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 is to be drawn and analysed for nitrate content. However, the surveyor may require an additional sample to be drawn and analysed at their 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. Requirements in respect of sampling, storage, handling and analysis are to be detailed in the ETM-A or ETM-B as applicable. To assure comparable nitrate discharge rate assessment, the sampling procedures are to take into account the provisions in 8.1.5(1) of this Chapter, which specifies the nitrates content normalized for the discharge water flow rate. Nitrates discharge data is to be presented as the difference between concentrations in the inlet water and in the discharge water. The analysis of nitrates is to be carried out according to standard seawater analysis as described in Methods of Seawater Analysis by Grasshoff et al. The test methods for nitrate are to be ISO 13395:1996, ISO 10304-1:2007, US EPA 353.2 or other internationally accepted equivalent test standard (suitable for seawater).

(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 the above (2) with the agreement of ISC based on an engineering analysis which demonstrates the design similarities in respect of nitrate concentrations in the discharge water.

8.1.6 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 on ballast water developed by IMO, 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.

8.1.7 Discharge water from temporary storage is to meet the following requirements:

(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 is to be monitored/recorded in accordance with 8.2.1 of this Chapter, and to meet, independent of any flow rate, the following discharge water criteria:

① pH See paragraph 8.1.2 of this Chapter;

② PAH Maximum of 50 μg/L PAHphe (phenanthrene equivalence) before any dilution for control of pH;

③ Turbidity Not greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, before any dilution for pH control

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

8.2 Discharge water monitoring

8.2.1 When the EGCS is operated in ports, harbours or estuaries, or during any discharges from temporary storage, the discharge water monitoring and recording is to be continuous. The values monitored and recorded are to include pH, PAH, turbidity and temperature. In other areas the continuous monitoring and recording equipment are also to 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 is to take place. Those EGCSs which apply degassing of the sampled discharge water for the purpose of turbidity monitoring are to ensure that particles do not settle during degassing, as this would underestimate the real turbidity value.

8.2.2 The permissible deviations of the discharge water monitoring equipment are not to exceed the following:

(1) pH 0.2 pH units;

(2) PAH 5% of nominal standard test concentration used. That nominal concentration value is to be not less than 80% of the scale range used;

(3) Turbidity 2 FNU or NTU.

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

8.2.3 The pH electrode and pH meter are to have a resolution of 0.1 pH units and temperature compensation. The electrode performance and accuracy is at least to comply with the requirements defined in BS 2586 or ASTM D1293-18 and the meter is to 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, and ensure at least a like-for-like level of requirements.

8.2.4 The PAH monitoring equipment are to be capable of monitoring PAH in water in a range to at least twice the discharge concentration limit given in Table 8.1.3 of this Chapter. The equipment are to be demonstrated to operate correctly and not deviate more than 5% in discharge water with turbidity within the working range of the application.

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

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

8.3 Approval of the discharge water monitoring systems

8.3.1 The discharge water monitoring system is to be approved by ISC.

8.4 Discharge water monitoring data recording

8.4.1 The data recording system is to comply with the requirements of 5.2 of Chapters 5 and Chapter 6 of the Guidelines and is to continuously record pH, PAH, turbidity in accordance with 8.2.1 of this Chapter at a frequency of not less than 0.0111 Hz.

8.4.2 Calibration and instrument drift data are to, 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.

8.5 EGCS residues

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

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

8.6 Maintenance and servicing records

8.6.1 The EGCS Record Book as required by either 3.7.9 of Chapter 3 or 4.7.3 of Chapter 4 is also to 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.

8.7 Design for water sampling points/valves

8.7.1 Each sampling point is to 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

Form:
格式:xxxxx

中 国 船 级 社
CHINA CLASSIFICATION SOCIETY

编号
No. ____

SO_x 排放符合证书
SO_x EMISSION COMPLIANCE CERTIFICATE
废气清洗系统认可证书 （SECC）
CERTIFICATE OF APPROVAL FOR EXHAUST GAS CLEANING SYSTEMS

本证书系根据国际防止船舶造成污染公约73/78（以下简称公约）经修订的1997议定书的规定，经政府授权，**由中国船级社颁发**。
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 related thereto under the authority of the Government of:

_____
by China Classification Society

兹证明:
This is to certify:
下列废气清洗（EGC）系统已按本指南中方案A的要求进行了检验。
That the exhaust gas cleaning (EGC) system listed below has been surveyed in accordance with the requirements of the specifications contained under Scheme A in the Guidelines.

本证书仅对下列的EGC有效。
This Certificate is valid only for the EGC system referred to below:

系统制造厂 System manufacturer	型号 Model/type	序列号 Serial number	经认证该EGC系统可等效于: This EGCS is certified as providing following equivalency: 燃油硫含量限值 Fuel oil sulphur limit values:	允许使用的最大硫含量燃油: Maximum sulphur content of fuel oils to be used:	EGC系统和方案A技术手册(ETM-A)批准号 EGC System Technical Manual for Scheme A（ETM-A）approval reference
			0.10%	____%/n/a*	
			0.50%	____%	
Note *: Delete as applicable.					

本证书的副本应一直保留在安装上述EGC系统的船上。
A copy of this Certificate shall be carried on board the ship fitted with this EGC System at all times.

经政府授权安装在船上的EGC系统，在整个使用生命周期内按照本指南第2章2.2和MARPOL公约附则VI第5条的规定接受检验时，本证书是有效的。
This Certificate is valid for the life of the EGC System subject to surveys in accordance with section 2.2, Chapter 2 of the Guidelines and regulation 5 of the revised MARPOL Annex VI, installed in ships under the authority of this Government.

发证地点
Issued at _____

_____

发证日期
Issued on

中国船级社验船师
Surveyor to China Classification Society

Appendix 2 Emission Ratio

1.1 This appendix is included to explain the background to the use of the emission ratio 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 corresponding to the fuel oil sulphur limits is also explained.

1.2 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.

1.3 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. 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.

1.4 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.

1.5 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, Chapter 6 of ISC Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines are taken as the starting points in Table 1.5 of this appendix. 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 Tables 1.5(1) and (2) 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.

Distillate fuel oil carbon content values **Table 1.5(1)**

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

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.

Residual fuel oil carbon content values **Table 1.5(2)**

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

1.6 From the derived carbon contents and selected sulphur content value the molar ratio of fuel sulphur to fuel carbon is obtained in Table 1.6 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. 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.

Emission ratio values for 1.50% sulphur fuel oil **Table 1.6**

			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	

1.7 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. For details see Table 1.7.

Emission ratios corresponding to fuel oil sulphur content ① **Table 1.7**

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

① 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 stipulated in the Guidelines are intended to act as initial guidance for implementing EGCS designs. The criteria is to 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 are therefore to provide 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

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 is to be equipped with sampling points for sampling of the following water streams:

(1) inlet water;

(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

(1) Sampling equipment

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

Table 2.1.3 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 are to be stored when drawn and when at the latest they need to reach the laboratory for analysis.

Recommendations on preparation for sampling bottles Table 2.1.3

Parameter	Bottle material	Volume	Method specifying sampling bottle requirements	Preservative	Storage temperature	Maximum time until analysis
NO2 -/NO3 -	PE	250 mL	ISO 10304-1	No preservative	Frozen (≤ -18°C)	8 days
Total Metals	PE	500 mL	ISO 17294-2	HNO3 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) 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.

(3) Preparation for transport

If samples need to be transported with ice packs, the ice packs are to 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.

(4) Preparation of personnel conducting the sampling

To ensure the health and safety of the personnel, it is recommended to wear the following equipment: protective eyeglasses/goggles, ear protection, gloves, protective clothing and safety shoes.

(5) Personnel qualifications and responsibilities.

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

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

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

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

(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 is to 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 is to be undertaken with the EGCS operating above 50% of maximum exhaust gas flow (see 3.6.1(2) ② of Chapter 3 and 4.6.1(2) ① of Chapter 4 of the Guidelines).

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) is to be steady before and during sampling;

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

(4) if more than one bottle is filled, the sampling valve is not to be closed in between;

(5) the use of any hydrocarbon-based cleaning agents at the sampling point is to 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 of this Appendix while sampling.

2.3 Transportation

Sampling equipment to be used during transportation is to meet provisions under 2.1.3(1) above.

2.3.1 Transportation container

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

2.3.2 Shipping to the laboratory

Samples are to be shipped to the laboratory as fast as possible. The transportation container is to 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 are to 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 is to 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 listed in Table 2.4.1 are recommended:

Methods for sample analysis **Table 2.4.1**

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 (NO3-/NO2-)	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 is to be determined by instant onboard measurements	Record pH mmediately on board	Record pH immediately on board
Note*: Preparation method is included in the analytical method.		

3 Recommended template for submitting sampling data

Instructions for the use of sampling data template:

(1) The submitted sampling data is to include information according to paragraphs 1 and 2 of this appendix as well as the results from the analyses as described under paragraph 2.4 of this Appendix.

(2) The following template is recommended for submitting sampling data.

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 are to 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 of EGCS (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	PAHphe	
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	—
Discharge point	Bottle # + time stamp	Bottle # + time stamp	—
—	—	—	—

Appendix 4 Standard Seawater Titration Curve

1.1 This appendix describes the chemical equilibrium model and the resulting titration curve (Figure 1.1 for the titration of curve pure seawater). The equilibrium model may include the effect of adding an additional alkali to the seawater (e.g. NaOH).

1.2 The titration curve in Figure 1.1 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.

1.3 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.

1.4 Based on an empirical equation fit to the EM curve, the fit equation for pure seawater can be obtained as follows:

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

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.

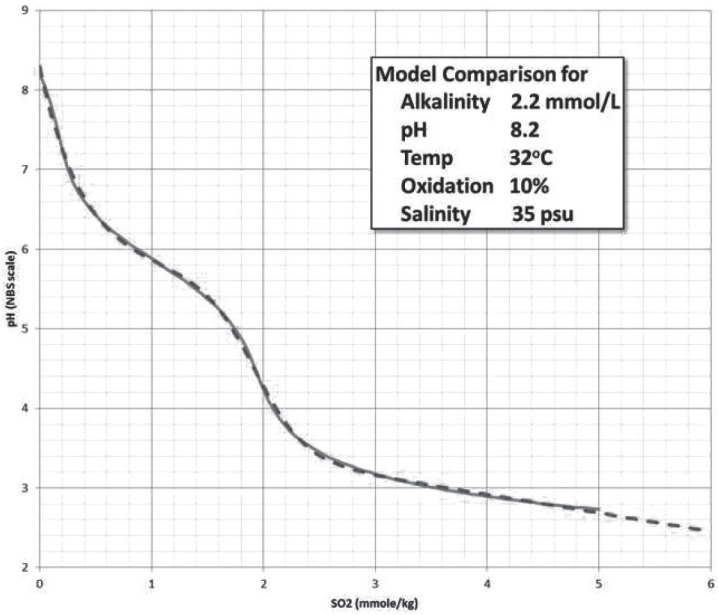

Figure 1.1 Pure seawater titration curve

Appendix 5 Analyser Information Templates

Instructions for the use of templates are as follows:

(1) In accordance with 6.2 in Chapter 6 of the Guidelines, OMM is to contain at least information related to surveys and inspections of the analyser. 6.2.2 in Chapter 6 of the Guidelines requires that information should be given in respect of the exhaust gas and discharge water analysers used in the respective monitoring systems.

(2) In order to provide a common approach to the above information and data, this appendix provides standard templates. These templates represent the minimum information which is to be given. Additional information may be required by ISC as appropriate.

(3) Users may voluntarily use the standard templates provided in this appendix which will assist all users of the OMM.

(1) Exhaust gas analyser

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.	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℃)	Yes/No	Yes/No
Sample line details	Length, inner diameter	Length, inner diameter

Cooler/dryer: Manufacturer Model reference		
Additional information		

(2) Water monitoring

pH/PAH/Turbidity*	
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:	Task/interval
service;	
maintenance;	
calibration.	
Additional information	
Note*: delete as applicable	

Appendix 6 Procedures for Handling in Case of EGCS Failure or Monitoring Instrument Failure

1 System malfunction

1.1 An Exhaust Gas Cleaning System (EGCS) malfunction is any condition that leads to an emission exceedance of EGCS, with the exception of the following:

(1) the short-term temporary emission exceedance cases described in 2.1 and 2.2 of this appendix;

(2) an interim indication of ongoing compliance in the case of sensor failure described in 3.1, 3.2 and 3.3 of this appendix.

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

1.3 The ship operator is to follow the process to identify and remedy the malfunction in the Exhaust Gas Cleaning System – Technical Manual or in other documentation provided by the EGCS manufacturer.

1.4 The trouble-shooting process specified by the EGCS manufacturer is to 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 is to 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 trouble-shooting process is to 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.

1.5 An EGCS malfunction event is to 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.

1.6 A system malfunction that cannot be rectified is regarded as a breakdown. The ship is to 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, is to be communicated to relevant authorities including the ship′s Administration and relevant port State for their agreement.

2 Short-term exceedances

2.1 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 has not malfunctioned. 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 is therefore not to be considered as a breach of the requirements.

2.2 The typical operating conditions that may result in a short-term temporary emission exceedance and the limits of these exceedances are to be specified by the EGCS manufacturer in the EGCS Technical Manual.

3 Interim indication of ongoing compliance in the case of sensor failure

3.1 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 Guidelines (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.

3.2 This interrelation 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.

3.3 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 are to 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 is to 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 is to 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 is to be repaired or replaced as soon as practicable.

4 Notifications

4.1 Any EGCS malfunction that lasts more than 1 hour or repetitive malfunctions is to 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 is to be communicated to the relevant port State to decide on appropriate action in accordance with the Convention.