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CHINA CLASSIFICATION SOCIETY

# GUIDELINES FOR TESTING AND SURVEY OF EXHAUST GAS CLEANING SYSTEMS

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## Chapter 1 General

### 1.1 Application and purpose

1.1.1 The Guidelines apply to the exhaust gas cleaning (hereinafter referred to as EGC) systems subject to surveys by China Classification Society (hereinafter referred to as CCS) 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 2015 Guidelines for Exhaust Gas Cleaning Systems, (Resolution MEPC.259(68)).

1.1.3 The Guidelines specify the requirements for testing, survey and certification and compliance verification of EGC systems, to demonstrate that SO<sub>x</sub> emissions from ships fitted with EGC systems are in compliance with regulations 14.1 and 14.4 of MARPOL Annex VI.

### 1.2 General requirements

1.2.1 For hydrocarbon fuels such as distillate or residual fuel there is correspondence between the fuel oil sulfur content and the ratio emission SO<sub>2</sub> (ppm)/CO<sub>2</sub>(%v/v). The SO<sub>2</sub>/CO<sub>2</sub> ratios corresponding to different fuel oil sulfur limits are shown in Table 1.2.1.

**Correspondence between fuel oil sulfur limits and SO<sub>2</sub>/CO<sub>2</sub> ratios Table 1.2.1**

SO <sub>2</sub> (ppm)/CO <sub>2</sub> (% v/v)	Fuel oil sulfur limits (% m/m)	Remarks
195.0	4.50	MARPOL Annex VI Reg.14.1.1
151.7	3.50	MARPOL Annex VI Reg. 14.1.2
65.0	1.50	MARPOL Annex VI Reg. 14.4.1
43.3	1.00	MARPOL Annex VI Reg. 14.4.2
21.7	0.50	MARPOL Annex VI Reg. 14.1.3
4.3	0.10	MARPOL Annex VI Reg. 14.4.3

1.2.2 Compliance of EGC systems is to be verified on the basis of the SO<sub>2</sub>/CO<sub>2</sub> ratio value measurements.

1.2.3 The use of the SO<sub>2</sub>/CO<sub>2</sub> ratio method is only applicable when using petroleum based distillate or residual fuel oils. See Appendix 2 to the Guidelines for application of the ratio method.

1.2.4 The discharge outlet of washwater used in the EGC unit is to be located as far from the ship's seawater inlet as possible. In all operating conditions the pH is to be maintained at a level that avoids damage to the vessel's anti-fouling system, the propeller, rudder and other components that may be vulnerable to acidic discharges, potentially causing accelerated corrosion of critical metal components.

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

1.2.6 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.

### 1.3 Definitions, abbreviations and symbols

#### 1.3.1 Definitions

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

(2) *Scheme A* means a survey and certification method to demonstrate the emissions compliance of EGC systems by test bed testing and parameter checks. See Chapter 3 of the Guidelines.

(3) *Scheme B* means a survey method to demonstrate the compliance of emissions from EGC systems by continuous monitoring of SO<sub>x</sub> emissions in exhaust gas. See Chapter 4 of the Guidelines.

(4) *Certified Value* means the SO<sub>2</sub>/CO<sub>2</sub> ratio specified by the manufacturer that the EGC unit is certified as meeting when operating on a continuous basis on the manufacturers specified maximum fuel sulphur content.

(5) *In Situ* means sampling directly within an exhaust gas stream of EGC systems.

(6) *Load range* means maximum rated power of diesel engine or maximum steaming rate of the boiler.

(7) *EGC Record Book* means a record of the EGC unit in-service operating parameters, component adjustments, maintenance and service records as appropriate.

#### 1.3.2 Abbreviations

(1) EGC: Exhaust Gas Cleaning.

(2) UTC: Universal Time Co-ordinated.

(3) MCR: Maximum Continuous Rating.

(4) SECP: SO<sub>x</sub> Emissions Compliance Plan.

(5) SECC: SO<sub>x</sub> Emissions Compliance Certificate.

(6) ETM-A: EGC System-Technical Manual for Scheme A.

(7) ETM-B: EGC System-Technical Manual for Scheme B.

(8) OMM: Onboard Monitoring Manual.

(9) GNSS: Global Navigational Satellite System.

### 1.3.3 Symbols

(1) SO<sub>x</sub>: Sulphur oxides.

(2) SO<sub>2</sub>: Sulphur dioxide.

(3) CO<sub>2</sub>: 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) **Product certification survey.** The EGC systems for which the application for the use of Scheme A is made are to be subject to product 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<sub>x</sub> 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 unit upon a satisfactory survey is to be issued with the SO<sub>x</sub> Emissions Compliance Certificate (SECC) by CCS. 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 unit 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 CCS 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 CCS. 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 CCS 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<sub>x</sub> 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 EGC system emission measurements and data recording, onboard monitoring manual, ship compliance, and washwater are to comply with the provisions in Chapters 5, 6, 7 and 8 of the Guidelines.

### **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<sub>x</sub> Emissions Compliance Plan (SECP);
- (2) EGC System-Technical Manual (ETM-A);
- (3) Onboard Monitoring Manual (OMM);
- (4) EGC Record Book or Electronic Logging System;
- (5) other documents and information as deemed necessary by CCS.

### **3.3 Approval of EGC systems**

#### **3.3.1 Unit approval**

An EGC unit is to be approved according to the following provisions:

(1) The EGC unit is to be demonstrated by testing as capable of meeting the certified 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 the Guidelines.

(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 permitted. The two fuels selected are to have a difference in % m/m sulphur content sufficient to demonstrate the operational behaviour of the EGC unit and to demonstrate that the certified value specified in 3.3.1(1) can be met if the EGC unit 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 as appropriate, are to be performed. These need not be sequential and could be undertaken on two different, but identical, EGC units.

(3) The maximum and, if applicable, minimum exhaust gas mass flow rate of the unit 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 EGC unit would be in excess of the certified value.

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

### 3.3.2 Approval of serially manufactured units

In the case of nominally similar EGC units of the same mass flow ratings as that certified under 3.3.1, and to avoid the testing of each EGC unit, the equipment manufacturer may submit, for acceptance by CCS, a conformity of production arrangement. The certification of each EGC unit under this arrangement is to be subject to such surveys that CCS may consider necessary as to assure that each EGC unit has an emission 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

Product range approval is to comply with the following requirements:

(1) In the case of an EGC unit of the same design, but of different maximum exhaust gas mass flow capacities, CCS may accept, in lieu of tests on an EGC unit of all capacities, tests of EGC systems 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 EGC units of different capacities, this procedure is not to be applied unless it can be shown that in practice those differences do not materially alter the performance between the various EGC unit types.

(3) For EGC units 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 EGC unit capacity on washwater characteristics is to be detailed.

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

## 3.4 Emission testing

3.4.1 EGC systems are to be subject to emission testing in accordance with 5.1 of Chapter 5.

3.4.2 Each EGC unit fitted to different fuel oil combustion equipment is to be capable of reducing emissions to equal to or less than the certified value at a load point within the load range specified in Table 3.4.2 when operated in accordance with the criteria as given within 3.6.1(2) of the Guidelines.

**Table 3.4.2**

<b>Fuel oil combustion equipment</b>	<b>Load range</b>
Main propulsion diesel engines	25% to 100%
Auxiliary diesel engines	10% to 100%
Diesel engines supplying power for both main propulsion and auxiliary purposes	10% to 100%
Boilers	10% to 100% <sup>①</sup>

Note: ① If the boiler turn down ratio is smaller, the actual load range of the boiler is to be taken.

3.4.3 In order to demonstrate performance of EGC systems, emission measurements are to be undertaken 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 unit is to be certified. One load point is to be within  $\pm 5\%$  of the minimum exhaust gas mass flow rate for which the unit 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 below the maximum exhaust gas mass flow rate and above, if applicable, the minimum exhaust gas flow rate. These additional tests are to be of sufficient number as to establish the emission peak value.

3.4.4 For loads below those specified in Table 3.4.2, the EGC unit is to continue in operation. In those cases where the fuel oil combustion equipment may be required to operate under idling conditions, the SO<sub>2</sub> emission concentration (ppm) at standardized O<sub>2</sub> concentration (15.0% diesel engines, 3.0% boilers) is not to exceed 50 ppm.

### **3.5 Certification**

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

3.5.2 Either prior to, or after installation on board, each EGC unit is to be demonstrated as meeting the certified value specified by the manufacturer under the operating conditions and restrictions as given by the ETM-A.

3.5.3 Each EGC unit meeting the requirements of 3.5.2 is to be issued with a SECC by CCS. The form of the SECC is given in Appendix 1.

3.5.4 Any subsequent EGC units 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.

3.5.5 EGC units 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.

3.5.6 EGC units 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 CCS to ensure that under all defined operating conditions the overall emission value of the exhaust gas down stream of the system is no more than the certified value.

### 3.6 EGC System Technical Manual (ETM-A)

3.6.1 Each EGC unit is to be supplied with an EGC System 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 unit (manufacturer, model/type, serial number and other details as necessary) including a description of the unit and any required ancillary systems;

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

- ① maximum and, if applicable, minimum mass flow rate of exhaust gas;
- ② the power, type and other relevant parameters of the fuel oil combustion unit for which the EGC unit is to be fitted. In the cases of boilers, the maximum air/fuel ratio at 100% load is also to be given. In the cases of diesel engines whether the engine is of 2 or 4-stroke cycle;
- ③ maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2);
- ④ exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGC unit in operation;
- ⑤ exhaust gas differential pressure range and the maximum exhaust gas inlet pressure with the fuel oil combustion unit operating at MCR or 80% of power rating whichever is appropriate;
- ⑥ salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and
- ⑦ other factors concerning the design and operation of the EGC unit;

(3) any requirement or restriction applicable to the EGC unit or associated equipment necessary to enable the unit to achieve a maximum emission value no higher than the certified value;

(4) maintenance, service or adjustment requirements in order that the EGC unit can continue to achieve its performance. The maintenance, servicing and adjustments are to be recorded in the EGC Record Book;

(5) corrective actions in case of exceedances of the applicable maximum allowable SO<sub>2</sub>/CO<sub>2</sub> ratio, or wash water discharge criteria;

(6) a verification procedure to be used at surveys to ensure that its performance is maintained and that the unit is used as required (see 3.7 of the Guidelines);

(7) through range performance variation in washwater characteristics;

(8) design requirements of the washwater system; and

(9) the SECC

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

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

3.6.4 Amendments to the ETM-A which reflect EGC unit changes that affect performance with respect to emissions to air and/or water are to be approved by CCS. 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 EGC unit, 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 EGC unit 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 those as approved, then the performance of the EGC system is within that required without the need for actual exhaust emission measurements. It is also necessary to ensure that the EGC unit is fitted to a fuel oil combustion unit for which it is rated – this forms part of the SO<sub>x</sub> Emissions Compliance Plan (SECP). A Technical File related to an Engine International Air Pollution Prevention (EIAPP) certificate, if available, or an Exhaust Gas Declaration issued by the engine maker or designer or another competent party or a Flue Gas Declaration issued by the boiler maker or designer or another competent party serves this purpose.

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

3.7.3 The verification procedure is to be submitted by the EGC system manufacturer and approved by CCS.

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

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

3.7.6 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, 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 EGC unit is to include means to automatically record when the system is in use. This is to automatically record, at least at the frequency specified in 4.4.2 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. The data recording system is to comply with the requirements of 5.2 and Chapter 6. In case of a unit consuming chemicals at a known rate as documented in ETM-A, records of such consumption in the EGC Record Book also serve this purpose.

3.7.8 Under Scheme A, if a continuous exhaust gas monitoring system is not fitted, it is recommended that a daily spot check of the exhaust gas quality in terms of SO<sub>2</sub> (ppm)/CO<sub>2</sub> (%) ratio, is used to verify compliance in conjunction with parameter checks stipulated in 3.7.7. If a continuous exhaust gas monitoring system is fitted, only daily spot checks of the parameters listed in 3.7.7 would be needed to verify proper operation of the EGC unit.

3.7.9 If the EGC system manufacturer is unable to provide assurance that the EGC unit will meet the certified value or below between surveys, by means of the verification procedure stipulated in 3.7.1, or if this requires specialist equipment or in-depth knowledge, it is recommended that continuous exhaust gas monitoring of each EGC unit be used (Scheme B) to assure compliance with MARPOL Annex VI regulations 14.1 and/or 14.4.

3.7.10 An EGC Record Book is to be maintained by the shipowner recording maintenance and service of the unit including like-for-like replacement. The form of this record is to be submitted by the EGC system manufacturer and approved by CCS. This EGC Record Book is to be available at surveys as required and may be read in conjunction with engine-room log-books and other data as necessary to confirm the correction operation of the EGC unit. Alternatively, this information is to be recorded in the vessel's planned maintenance record system as approved.

## **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 is to be used to demonstrate that the emissions from a fuel oil combustion unit fitted with an EGC will, with that system in operation, result in the required emission value (e.g., as stated in the SECP) or below at any load point, including during transient operation and thus compliance with the requirements of regulations 14.1 and/or 14.4 of MARPOL Annex VI.

4.1.3 EGC systems emission measurements and data recording, onboard monitoring manual, ship compliance and washwater are to comply with the provisions in Chapters 5, 6, 7 and 8 of the Guidelines.

### **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<sub>x</sub> Emissions Compliance Plan (SECP);
- (2) EGC System-Technical Manual (ETM-B);
- (3) Onboard Monitoring Manual (OMM);
- (4) EGC Record Book or Electronic Logging System;
- (5) other documents as deemed necessary by CCS.

### **4.3 Approval**

4.3.1 Where Scheme B is adopted, compliance of emissions from ships fitted with EGC systems are to be verified by continuous exhaust gas monitoring. Monitoring system is to be approved by CCS and the results of that monitoring are to be adequate to demonstrate compliance as required.

### **4.4 Emission measurements**

4.4.1 Exhaust gas composition in terms of SO<sub>2</sub> (ppm)/CO<sub>2</sub> (%) is to be measured at an appropriate position after the EGC unit and that measurement is to be in accordance with the requirements of 5.2 of the Guidelines as applicable.

4.4.2 SO<sub>2</sub> (ppm) and CO<sub>2</sub> (%) are to be continuously monitored and recorded onto a data recording and processing device at a rate which is not to be less than 0.0035 Hz.

4.4.3 If more than one analyser is to be used to determine the SO<sub>2</sub>/CO<sub>2</sub> ratio, these are to be tuned to have similar sampling and measurement times and the data outputs aligned so that the SO<sub>2</sub>/CO<sub>2</sub> ratio is fully representative of the exhaust gas composition.

#### **4.5 Onboard verification procedures**

4.5.1 Daily spot checks of the parameters listed in 3.7.7 are needed to verify proper operation of the EGC unit and are to be recorded in the EGC Record Book or in the engine-room logger system.

4.5.2 The data recording system is to comply with the requirements of 5.2 of Chapter 5 and Chapter 6.

#### **4.6 EGC System Technical Manual (ETM-B)**

4.6.1 Each EGC unit 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 unit (manufacturer, model/type, serial number and other details as necessary) including a description of the unit and any required ancillary systems;

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

- ① maximum and, if applicable, minimum mass flow rate of exhaust gas;
- ② the power, type and other relevant parameters of the fuel oil combustion unit for which the EGC unit is to be fitted. In the cases of boilers, the maximum air/fuel ratio at 100% load is also to be given. In the cases of diesel engines whether the engine is of 2 or 4-stroke cycle;
- ③ maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2);
- ④ exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGC unit in operation;
- ⑤ exhaust gas differential pressure range and the maximum exhaust gas inlet pressure with the fuel oil combustion unit operating at MCR or 80% of power rating whichever is appropriate;
- ⑥ salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and
- ⑦ other parameters as necessary concerning the operation of the EGC unit;

(3) any requirement or restriction applicable to the EGC unit or associated equipment necessary to enable the unit to achieve a maximum emission value no higher than the certified value;

(4) through range performance variation in washwater characteristics;

(5) design requirements of the washwater system.

**4.6.2 The ETM-B is to be approved by CCS.**

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

4.6.4 Amendments to the ETM-B which reflect EGC unit changes that affect performance with respect to emissions to air and/or water are to be approved by CCS. 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.

## **Chapter 5 Emission Measurements, Data Recording and Processing Device**

### **5.1 Emission measurements**

5.1.1 In addition to the requirements provided in the Guidelines, emission measurements are to follow the requirements of Chapter 5 and associated Appendices of CCS Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines, 2015.

5.1.2 CO<sub>2</sub> 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<sub>2</sub> 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 CCS, provided they yield equivalent or better results to those of the equipment referenced above. For acceptance of other CO<sub>2</sub> systems or analyser principles, the reference method is to be in accordance with the requirements of Appendix 7 of CCS Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines, 2015.

5.1.3 Analyser performance is to be in accordance with the requirements of Sections 1.6 to 1.10 of Appendix 7 of CCS Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines, 2015.

5.1.4 An exhaust gas sample for SO<sub>2</sub> is to be obtained from a representative sampling point downstream of the EGC unit.

5.1.5 SO<sub>2</sub> and CO<sub>2</sub> are to be monitored using either in situ or extractive sample systems.

5.1.6 Extractive exhaust gas samples for SO<sub>2</sub> determination are to be maintained at a sufficient temperature to avoid condensed water in the sampling system and hence loss of SO<sub>2</sub>.

5.1.7 If an extractive exhaust gas sample for determination needs to be dried prior to analysis it is not to be done in a manner that does not result in loss of SO<sub>2</sub> in the sample as analysed.

5.1.8 The SO<sub>2</sub> and CO<sub>2</sub> 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<sub>2</sub> concentration is reduced by the EGC unit, the CO<sub>2</sub> 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<sub>2</sub> and CO<sub>2</sub> 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<sub>2</sub> value on a dry basis, the dry/wet correction factor may be calculated in accordance with 5.7.1.2(2) of CCS Guidelines for Testing and Survey of Emission of Nitrogen Oxides from Marine Diesel Engines, 2015.

### **5.2 Data recording and processing device**

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

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

5.2.3 The recording and processing device are to record the data required by 3.7.7, 4.4.2, and 8.3 against UTC and ships position by a Global Navigational Satellite System (GNSS).

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 unit is changed over that period, the shipowner is to ensure that the required data is retained on board and available as required.

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 EGC unit installed in conjunction with fuel oil combustion equipment, which is to be identified, for which compliance is to be demonstrated.

6.1.2 The OMM is to specify how the monitoring is to be surveyed.

### **6.2 OMM**

6.2.1 The OMM is to, as a minimum, include:

- (1) the sensors to be used in evaluating EGC system performance and washwater monitoring, their service, maintenance and calibration requirements;
- (2) the positions from which exhaust emission measurements and washwater monitoring are to be taken together with details of any necessary ancillary services such as sample transfer lines and sample treatment units and any related service or maintenance requirements;
- (3) the analysers to be used, their service, maintenance, and calibration requirements;
- (4) analyser zero and span check procedures; and
- (5) other information or data relevant to the correct functioning of the monitoring systems or its use in demonstrating compliance.

## **Chapter 7 Ship Compliance**

### **7.1 SO<sub>x</sub> Emissions Compliance Plan (SECP)**

7.1.1 For all ships which are to use an EGC unit to clean SO<sub>x</sub> emissions, in part or in total, in order to comply with the requirements of regulations 14.1 and 14.4 of MARPOL Annex VI there is to be a SO<sub>x</sub> Emissions Compliance Plan (SECP) for the ship, approved by CCS.

7.1.2 The SECP is to list each item of fuel oil combustion equipment which is to meet the requirements of MARPOL Annex VI.

7.1.3 Under Scheme A, the SECP is to present how continuous monitoring data will demonstrate that the parameters in paragraph 3.7.7 are maintained within the manufacturer's recommended specifications. Under Scheme B, this would be demonstrated using daily recordings of key parameters.

7.1.4 Under Scheme B, the SECP is to present how continuous exhaust gas emissions monitoring will demonstrate that the ship total SO<sub>2</sub> (ppm)/CO<sub>2</sub> (%) ratio is not to exceed the limits prescribed in 1.2.1 of the Guidelines. Under Scheme A, this would be demonstrated using daily exhaust gas emission recordings.

7.1.5 There may be some equipment such as small engines and boilers to which the fitting of EGC units would not be practical, particularly where such equipment is located in a position remote from the main machinery spaces. All such fuel oil combustion units are to be listed in the SECP. For these fuel oil combustion units which are not to be fitted with EGC units, compliance may be achieved by using the fuel oil as required in regulations 14.1 and/or 14.4 of MARPOL Annex VI.

### **7.2 Demonstration of compliance**

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

(1) The SECP is to refer to the ETM-A, EGC Record Book or Engine-Room logger system and OMM as specified in Chapter 3 of the Guidelines. It is to be noted that as an alternative, the maintenance records may be recorded in the ship's Planned Maintenance Record System as approved.

(2) For all fuel oil combustion equipment listed under 7.1.2, details are to be provided demonstrating that the rating and restrictions for the EGC unit specified in 3.6.1(2) are complied with.

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

7.2.2 The SECP is to refer to the ETM-B, EGC Record Book or Engine-Room logger system and OMM as specified in Chapter 4 of the Guidelines.

## Chapter 8 Washwater

### 8.1 Washwater discharge criteria<sup>①</sup>

8.1.1 When the EGC system is operated in ports, harbours, or estuaries, the washwater monitoring and recording are 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 EGC system is in operation, except for short periods of maintenance and cleaning of the equipment. The discharge water pH, PAH, turbidity, content of nitrates, additives and other substances are to comply with the requirements of 8.1.2 to 8.1.6 respectively.

8.1.2 The washwater 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 washwater is to have a pH of no less than 6.5 measured at the ship's overboard discharge with the exception that during manoeuvring and transit, the maximum difference between inlet and outlet of 2 pH units is allowed measured at the ship's inlet and overboard discharge.

(2) The pH discharge limit, at the overboard monitoring position, is the value that will achieve as a minimum pH 6.5 at 4 m from the overboard discharge point with the ship stationary, and which 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 CCS, 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 the fuel oil of a 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 washwater 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 washwater plume and that the overboard pH discharge limit has been met if the EGC system is operated at the highest fuel sulphur content and load for which the EGC system is certified (Scheme A) or use with (Scheme B);
- ③ where the washwater flow rate is varied in accordance with the EGC system 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  $\mu\text{mol/litre}$  and pH 8.2<sup>①</sup>; an amended titration curve is to be applied where the testing conditions differ from the reference seawater, as agreed by CCS; and

Note ①: These values could be revised within two years for new installations following the adoption of 2015 Guidelines for Exhaust Gas Cleaning Systems upon further inputs on the physical state of the seas resulting from the use of exhaust gas cleaning systems.

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① The washwater discharge criteria may be revised in the future as more data becomes available on the contents of the discharge and its effects.

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

8.1.3 The washwater 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 washwater is not to be greater than 50 µg/L above the inlet water PAH concentration. For the purposes of this criteria, the PAH concentration in the washwater is to be measured downstream of the water treatment equipment, but upstream of any washwater dilution or other reactant dosing unit, if used, prior to discharge.

(2) The 50 µg/L limit described above is normalized for a washwater flow rate through the EGC unit of 45t/MWh where the MW refers to the MCR or 80% of the power rating of the fuel oil combustion unit. The correspondence between this limit and washwater flow rates is given in Table 8.1.3.

**Washwater PAH concentration limit** **Table 8.1.3**

Flow rate (t/MWh)	PAH concentration limit (µg/L)	Measurement technology
0 - 1	2250	Ultraviolet light
2.5	900	Ultraviolet light
5	450	Fluorescence <sup>②</sup>
11.25	200	Fluorescence
22.5	100	Fluorescence
45	50	Fluorescence
90	25	Fluorescence

Note:② For any flow rate > 2.5 t/MWh, fluorescence technology is to be used.

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

8.1.4 The washwater turbidity/suspended particle matter is to comply with the following requirements. The limit is to be recorded in the ETM-A or ETM-B.

(1) The washwater treatment system is to be designed to minimize suspended particulate matter, including heavy metals and ash.

(2) The maximum continuous turbidity in washwater is not to be greater than 25 FNU (formazin nephelometric units) or 25 NTU (nephelometric 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 15-minute period to a maximum of 25 FNU. For the purposes of this criteria the turbidity in the washwater is to be measured downstream of the water treatment equipment but upstream of washwater dilution (or other reactant dosing) prior to discharge.

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

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

(1) The washwater treatment system is to prevent the discharge of nitrates beyond that associated with a 12% removal of NO<sub>x</sub> from the exhaust, or beyond 60 mg/l normalized for a washwater flow rate of 45 tons/MWh, whichever is greater.

(2) At each renewal survey nitrate discharge data is to be available in respect of sample overboard discharge drawn from each EGC system with the previous three months prior to the survey. 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 EGC Record Book and 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 8.1.5(1), which specifies the correspondence between washwater flow rate and nitrate discharge concentration limit. The test method for the analysis of nitrates is to be according to standard seawater analysis as described in Methods of Seawater Analysis by Grasshoff et al.

(3) All systems are to be tested for nitrates in the discharge water. If typical nitrate amounts are above 80% of the upper limit, it is to be recorded in the ETM-A or ETM-B.

8.1.6 An assessment of the washwater is required for those EGC technologies which make use of chemicals, additives, preparations or create relevant chemicals in situ. The assessment could take into account relevant guidelines such as resolution MEPC.126(53), procedure for approval of ballast water management systems that make use of active substances (G9) and if necessary additional washwater discharge criteria is to be established.

## **8.2 Washwater monitoring**

8.2.1 The pH, oil content (as measured by PAH levels), turbidity and temperature are to be continuously monitored and recorded as recommended in 5.2 of the Guidelines. The monitoring equipment is also to meet the performance criteria described in 8.2.2 to 8.2.5.

8.2.2 The pH electrode and pH meter are to have a resolution of 0.1 pH units and temperature compensation. The electrode is to comply with the requirements defined in BS 2586 or of equivalent or better performance and the meter is to meet or exceed BS EN ISO 60746-2:2003.

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

8.2.4 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.

8.2.5 The turbidity monitoring equipment is to meet requirements defined in ISO 7027:1999 or USEPA 180.1.

### **8.3 Washwater monitoring data recording**

8.3.1 The data recording system is to comply with the requirements of Chapters 5.2 and 6 of the Guidelines and is to continuously record pH, PAH, turbidity and temperature.

### **8.4 Washwater residue**

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

8.4.2 Each ship fitted with an EGC unit is to record the storage and disposal of washwater residues in an EGC log, including the date, time and location of such storage and disposal. The EGC log may form a part of an existing log-book or electronic recording system.

**Appendix 1**  
**Form of SO<sub>x</sub> Emission Compliance Certificate**

中国船级社  
CHINA CLASSIFICATION SOCIETY

**Form:**  
格式:xxxxx

编号  
No. \_\_\_\_\_

**SO<sub>x</sub>排放符合证书**  
**SO<sub>x</sub> EMISSION COMPLIANCE CERTIFICATE (SECC)**  
**废气清洗系统认可证书**  
**CERTIFICATE OF UNIT 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2008年MEPC.176(58)决议修订的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 by resolution MEPC.176(58) in 2008, 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）装置已按本指南中方案A的要求进行了检验。

That the exhaust gas cleaning (EGC) unit 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装置有效。

This Certificate is valid only for the EGC unit referred to below:

装置制造厂 Unit manufacturer	型号 Model/type	序列号 Serial number	EGC装置和技术手册认可号 EGC System Unit and Technical Manual approval number

本证书的副本应与EGC系统技术手册一起，一直保留在安装上述EGC装置的船上。

A copy of this Certificate, together with the EGC System Technical Manual, shall be carried on board the ship fitted with this EGC System unit at all times.

经政府授权安装在船上的EGC装置，在整个使用生命周期内按照本指南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 unit subject to surveys in accordance with section 2.2 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 The SO<sub>2</sub>/CO<sub>2</sub> Ratio Method

1 The SO<sub>2</sub>/CO<sub>2</sub> ratio method enables direct monitoring of exhaust gas emissions to verify compliance with emissions limits set out in Table 1.2.1 of the Guidelines. In the case of EGC systems that absorb CO<sub>2</sub> during the exhaust gas cleaning process it is necessary to measure the CO<sub>2</sub> prior to the cleaning process and use the CO<sub>2</sub> concentration before cleaning with the SO<sub>2</sub> concentration after cleaning to calculate the SO<sub>2</sub>/CO<sub>2</sub> ratio. For conventional low alkali cleaning systems virtually no CO<sub>2</sub> is absorbed during exhaust gas cleaning and therefore measurement of both gases can be undertaken after the cleaning process.

2 For this group of hydrocarbon distillate and residual fuel the carbon content as a percentage of mass remains closely similar, whereas the hydrogen content differs. Thus it can be concluded that for a given carbon consumption by combustion there will be a consumption of sulphur in proportion to the sulphur content of the fuel, or in other words a constant SO<sub>2</sub>/CO<sub>2</sub> ratio.

3 The limit of 65 (ppm/%) SO<sub>2</sub>/CO<sub>2</sub> for 1.5% sulphur in fuel can be demonstrated by first calculating the mass ratio of fuel sulphur to fuel carbon, which is tabulated in Table 1 in this appendix. These ratios were used to solve for the corresponding SO<sub>2</sub> and CO<sub>2</sub> concentrations in exhaust, which are tabulated in Table 2 of this Appendix. Molecular weights (MW) were taken into account to convert mass fractions to mole fractions. For the 1.5% sulphur fuels in Table 2, the amount of CO<sub>2</sub> is set first at 8% and then changed to 0.5% to show that there is no effect due to changes in excess air. As expected, the absolute SO<sub>2</sub> concentration changes, but the SO<sub>2</sub>/CO<sub>2</sub> ratio does not. This indicates that the SO<sub>2</sub>/CO<sub>2</sub> ratio is independent of fuel-to-air ratios. Therefore, SO<sub>2</sub>/CO<sub>2</sub> ratio can be used robustly at any point of operation, including operation where no brake power is produced.

Table 2 shows that the SO<sub>2</sub>/CO<sub>2</sub> ratio varies slightly from distillate to residual fuel both containing 1.5% sulphur. This occurs because of the very different atomic hydrogen-to-carbon ratios (H:C) of the two fuels. Figure 1 illustrates the extent of the SO<sub>2</sub>/CO<sub>2</sub> ratios' sensitivity to H:C over a broad range of H:C and fuel sulphur concentrations. From Figure 1, it can be concluded that for fuel sulphur levels less than 3.00%, the difference in S/C ratios for distillate and residual fuel is less than 5.0%.

In the case of using non-petroleum fuel oils, the appropriate SO<sub>2</sub>/CO<sub>2</sub> ratio applicable to the values given in regulations 14.1 and/or 14.4 will be subject to approval by CCS.

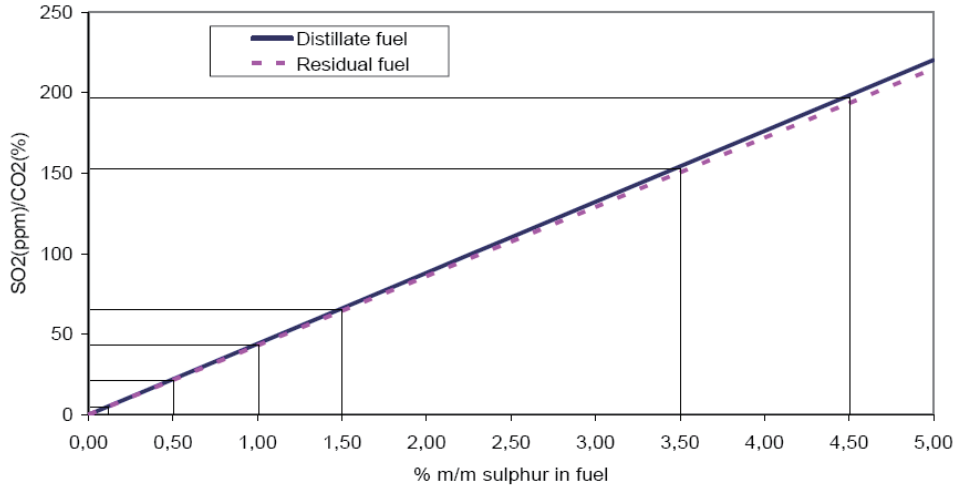
**Fuel properties for marine distillate and residual fuel<sup>①</sup> Table 1**

	Carbon	Hydrogen	Sulphur	Other	C	H	S	Fuel S/C	Exh SO <sub>2</sub> /CO <sub>2</sub>
Fuel type	%(m/m)	%(m/m)	%(m/m)	%(m/m)	mol/kg	mol/kg	mol/kg	mol/mol	ppm/%(v/v)
Distillate	86.20	13.60	0.17	0.03	71.8333	136	0.0531	0.00074	7.39559
Residual	86.10	10.90	2.70	0.30	71.7500	109	0.8438	0.01176	117.5958
Distillate	85.05	13.42	1.50	0.03	70.8750	134.2	0.4688	0.006614	66.1376
Residual	87.17	11.03	1.50	0.30	72.6417	110.3	0.4688	0.006453	64.5291

① Based on properties in the Guidelines for On-board NO<sub>x</sub> Verification Procedure - Direct Measurement and Monitoring Method, resolution MEPC.103(49).

**Emissions calculations corresponding to 1.5% fuel sulphur Table 2**

	S % (m/m)	CO <sub>2</sub> (%)	SO <sub>2</sub> (ppm)	Exh SO <sub>2</sub> /CO <sub>2</sub> (ppm/%)	Exh S/C (m/m)
Distillate	0.17	8	59.1	7.4	0.00197
Residual	2.70	8	939.7	117.5	0.03136
Distillate	1.5	8	528.5	<b>66.1</b>	<b>0.01764</b>
Residual	1.5	8	515.7	<b>64.5</b>	<b>0.01721</b>
Distillate	1.5	0.5	33.0	<b>66.1</b>	<b>0.01764</b>
Residual	1.5	0.5	32.2	<b>64.5</b>	<b>0.01721</b>



**Figure 1 SO<sub>2</sub>/CO<sub>2</sub> ratio vs % sulphur in fuel**

4 For 1.5% sulphur distillate and residual fuels, correspondence between 65 (ppm/%) SO<sub>2</sub>/CO<sub>2</sub> and 6.0 g/kWh is demonstrated by showing that their S/C ratios are similar. This requires an additional assumption of a brake-specified fuel consumption value of 200 g/kWh. This is an appropriate average for marine diesel engines. The calculation of  $\left(\frac{S}{C}\right)_{fuel}$  is as follows:

$$\left(\frac{S}{C}\right)_{fuel} = \frac{SO_{2,BSFC} \times (MW_S / MW_{SO_2})}{BSFC \times C_{fuel}}$$

where: *BSFC* — brake-specified fuel consumption value, taken as 200 g/kWh;  
*SO<sub>2,BSFC</sub>* — assuming a diesel engine *BSFC* value of 200 g/kWh, the exhaust SO<sub>2</sub> limit discharged from combustion of 1.5% sulfur fuel, taken as 6.0 g/kWh;  
*MW<sub>S</sub>* — mass of sulphur in terms of mol, taken as 32.065 g/mol;  
*MW<sub>SO<sub>2</sub></sub>* — mass of SO<sub>2</sub> in terms of mol, taken as 64.064 g/mol;  
*C<sub>fuel</sub>* — % carbon in 1.5% S fuel, taken as 85.05% for distillate and 87.17% for residual (see Table 1).

The *S/C* mass ratios calculated above for 1.5% *S* distillate and residual fuels are 0.01765 and 0.01723 respectively, which are both within 0.10% of the *S/C* mass ratios in the emissions table (Table 2). Therefore, 65 (ppm/%) SO<sub>2</sub>/CO<sub>2</sub> limit corresponds well to 6.0 g/kWh SO<sub>2</sub> limit.

The value of 6.0 g/kWh SO<sub>2</sub> limit, hence the 200 g/kWh brake-specified fuel consumption is taken from MARPOL Annex VI.

5 The SO<sub>2</sub>/CO<sub>2</sub> ratio in exhaust gas emissions after combustion of fuel is calculated as follows:

For complete combustion:

$$\frac{SO_2(ppm)}{CO_2(\%)} \leq 65$$

For incomplete combustion:

$$\frac{SO_2(ppm)}{CO_2(\%) + (CO(ppm) / 10000) + (THC(ppm) / 10000)} \leq 65$$

Note: Gas concentrations used for the above calculation are to be sampled or converted to the same residual water content (e.g., fully wet, fully dry).

6 The following is the basis of using the <sup>①</sup>ppm/%) SO<sub>2</sub>/CO<sub>2</sub> limit for determining compliance of SO<sub>x</sub> emissions with MARPOL Annex VI:

- (1) The SO<sub>2</sub>/CO<sub>2</sub> limit can be used to determine compliance from fuel oil burners that do not produce mechanical power.
- (2) The SO<sub>2</sub>/CO<sub>2</sub> limit can be used to determine compliance at any power output, including idle.
- (3) The SO<sub>2</sub>/CO<sub>2</sub> limit only requires two gas concentration measurements at one sampling location.
- (4) Where this limit is used, there is no need to measure any engine parameters such as engine speed, engine torque, engine exhaust flow, or engine fuel flow.
- (5) If both gas concentration measurements are made at the same residual water content in the sample (e.g., fully wet, fully dry), no dry-to-wet conversion factors are required in the calculation of SO<sub>2</sub>/CO<sub>2</sub>.
- (6) This limit completely decouples the thermal efficiency of the fuel oil combustion unit from the EGC unit.
- (7) No fuel properties need to be known.
- (8) Because only two measurements are made at a single location, transient engine or EGCS unit effects can be minimized by aligning signals from just these two analysers.
- (9) This SO<sub>2</sub>/CO<sub>2</sub> limit is independent of the amount of exhaust gas dilution. Dilution may occur due to evaporation of water in an EGC unit, and as part of an exhaust sampler's preconditioning system.

<sup>①</sup> ppm means "parts per million". It is assumed that ppm is measured by gas analysers on a molar basis, assuming ideal gas behaviour. The technically correct units are actually micro-moles of substance per mole of total amount (μmol/mol).

### **Appendix 3 Washwater Data Collection**

The washwater discharge criteria introduced in the Guidelines are intended to act as initial guidance for implementing EGC system designs. The criteria may be revised in the future as more data becomes available on the contents of the discharge and its effects. Administrations are therefore to provide for collection of relevant data. To this end, shipowners in conjunction with the EGC manufacturer are requested to sample and analyse samples of inlet water, water after the scrubber (but before any treatment system) and discharge water.

This sampling could be made during approval testing or shortly after commissioning and at about twelve-month intervals for a period of two years of operation (minimum of three samples). Sampling guidance and analysis are to be undertaken by laboratories using EPA or ISO test procedures for the following parameters: pH, PAH, Nitrate, Nitrite, Cd, Cu, Ni, Pb, Zn, As, Cr, V. The extent of laboratory testing may be varied or enhanced in the light of developing knowledge.

When submitting sample data, information is also to be included on washwater discharge flow rates, dilution of discharge, if applicable, and engine power is to be included as well as specifications of the fuel as a minimum.

It is recommended that the ship that has provided this information is to be granted a waiver for compliance of the existing installation(s) to possible future stricter washwater discharge standards. The Administration is to forward information submitted on this issue to IMO for dissemination by the appropriate mechanisms.