ANNEX 4

RESOLUTION MEPC.170(57)

Adopted on 4 April 2008

GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

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

RECALLING ALSO that the Conference of Parties to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), held in September 1997, adopted the Protocol of 1997 to amend MARPOL 73/78 with the addition of Annex VI on the Prevention of Air Pollution from Ships,

NOTING that the 1997 Conference, by regulation 14(4)(b) of Annex VI, agreed that ships within a SOx emission control area (SECA) are permitted to operate with an exhaust gas cleaning system approved by the Administration and taking into account guidelines to be developed by the Organization,

BEING AWARE that the Protocol of 1997 entered into force on 19 May 2005 and that exemptions from the requirements for SECAs, in accordance with regulation 14(7) of Annex VI ceased on 18 May 2006 for the Baltic Sea SECA and on 22 November 2007 for the North Sea SECA,

RECALLING resolution MEPC.130(53) by which the Committee adopted the Guidelines for Onboard Exhaust Gas-SOx Cleaning Systems,

HAVING CONSIDERED the draft amendments to the Guidelines for Exhaust Gas Cleaning Systems prepared by the Sub-Committee on Bulk Liquids and Gases and finalized at its twelfth session;

1. ADOPTS the Guidelines for Exhaust Gas Cleaning Systems, as set out in the annex to this resolution;

2. INVITES Governments to apply the Guidelines from the date of their adoption; and

3. REVOKES the Guidelines adopted by resolution MEPC.130(53).

ANNEX

GUIDELINES FOR EXHAUST GAS CLEANING SYSTEMS

1 INTRODUCTION

1.1 Regulation 14(4) of Annex VI to MARPOL 73/78 requires ships within SOx emission control areas to either use fuel oil with a sulphur content not exceeding that stipulated in regulation 14(4)(a) or apply an exhaust gas cleaning (EGC) system to reduce the total emission of SO_x to that stipulated in regulation 14(4)(b). The EGC unit should to be approved by the Administration taking into account these guidelines.

1.2 Similar to a NOx emission reduction system, an EGC unit may be approved subject to periodic parameter and emission checks or the system may be equipped with a continuous emission monitoring system. These guidelines have been developed with the intention of being objective and performance oriented. As an alternative, introduction of the SO_2 (ppm)/CO_2 (%) ratio method will simplify the monitoring of SOx emission and facilitate approval of an EGC unit. See Appendix I for the rationale explaining the use of SO_2 (ppm)/CO_2 (%) as the basis for system monitoring.

1.3 These Guidelines are recommendatory in nature, however, Administrations are invited to base their implementation on these guidelines.

2 GENERAL

2.1 Purpose

2.1.1 The purpose of these Guidelines is to specify the requirements for the testing, survey certification and verification of exhaust gas cleaning (EGC) systems to ensure that they comply with the requirements of regulation 14(4)(b) of Annex VI of MARPOL 73/78.

2.1.2 The Guidelines permit two schemes; Scheme A (Unit Certification with Parameter and Emission Checks, and Scheme B (Continuous Emission Monitoring with Parameter Checks).

2.1.3 For ships which are to use an exhaust gas cleaning system in part or in total in order to comply with regulation 14(4)(b) of MARPOL Annex VI there should be an approved SECA Compliance Plan (SCP).

2.2 Application

2.2.1 These Guidelines apply to any EGC unit as fitted to fuel oil combustion machinery, excluding shipboard incinerators, installed on board a ship.

2.3 Definitions and Required Documents

Fuel oil combustion unit	Any engine, boiler, gas turbine, or other fuel oil fired equipment, excluding shipboard incinerators
ppb	Parts per billion
SECA	SOx Emission Control Area
UTC	Universal Time Co-ordinated
Certified value	That emission limit specified by the manufacturer that the EGC unit is certified as meeting
In-situ	Sampling directly within an exhaust gas stream
MCR	Maximum Continuous Rating
SCP	SECA Compliance Plan
SCC	SECA Compliance Certificate.
ETM "Scheme A"	EGC – SOx Technical Manual for Scheme A
ETM "Scheme B"	EGC – SOx Technical Manual for Scheme B
OMM	Onboard Monitoring Manual
EGC Record book	A record of the EGC unit in-service operating parameters, component adjustments, maintenance and service records as appropriate.

Document	Scheme A	Scheme B
SCP	X	X
SCC	X	
ETM Scheme A	X	
ETM Scheme B		X
OMM	X	X
EGC Record Book or Electronic Logging System	X	X
Oil Record Book	X	X

3 SAFETY NOTE

3.1 Due attention is to be given to the safety implications related to the handling and proximity of exhaust gases, the measurement equipment and the storage and use of cylindered pure and calibration gases. Sampling positions and access staging should be such that this monitoring may be performed safely. In locating discharge outlet of washwater used in the EGCS unit, due consideration should be given to the location of the ship's seawater inlet. In all operating conditions the pH should be maintained at a level that avoids damage to the vessel's antifouling system, the propeller, rudder and other components that may be vulnerable to acidic discharges, potentially causing accelerated corrosion of critical metal components.

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

4.1 Approval of EGC systems

4.1.1 General

Options under Scheme A of these Guidelines provide for:

a) Unit approval;
b) Serially manufactured units;
c) Production range approval.

4.1.2 Unit approval

4.1.2.1 An EGC unit should be certified as capable of meeting the limit value, (the certified value), specified by the manufacturer (e.g., the emission level the unit is capable of achieving on a continuous basis) with fuel oils of up to highest allowable global % m/m sulphur content under MARPOL Annex VI regulation 14(1) and for the range of operating parameters, as listed in 4.2.2.1(b), for which they are to be approved.

4.1.2.2 Where testing is not to be undertaken with fuel oils of the highest allowable global % m/m sulphur content the use of two test fuels with a lower % m/m sulphur content is permitted. The two fuels selected should have a difference in % m/m sulphur content sufficient to demonstrate the operational behaviour of the EGC unit and to demonstrate that the requirements of MARPOL Annex VI regulation 14(4) can be met if the EGC unit were to be operated with a fuel of the highest allowable global % m/m sulphur content under MARPOL Annex VI, regulation 14(1). In such cases a minimum of two tests, in accordance with section 4.3 as appropriate, should be performed. These need not be sequential and could be undertaken on two different, but identical, EGC units.

4.1.2.3 The maximum and, if applicable, minimum exhaust gas mass flow rate of the unit should be stated. The effect of variation of the other parameters defined in 4.2.2.1(b) should be justified by the equipment manufacturer. The effect of variations in these factors should be assessed by testing or otherwise as appropriate. No variation in these factors, or combination of variations in these factors, should be such that the emission value of the EGC unit would be in excess of the certified value.

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

4.1.3 Serially manufactured units

In the case of nominally similar EGC units of the same mass flow ratings as that certified under 4.1.2, and to avoid the testing of each EGC unit, the equipment manufacturer may submit, for acceptance by the Administration, a conformity of production arrangement. The certification of each EGC unit under this arrangement should be subject to such surveys that the Administration may consider necessary as to assure that each EGCS unit has an emission value of not more than the certified value when operated in accordance with the parameters defined in 4.2.2.1(b).

4.1.4 Product range approval

4.1.4.1 In the case of an EGC unit of the same design, but of different maximum exhaust gas mass flow capacities, the Administration may accept, in lieu of tests on an EGC unit of all capacities in accordance with section 4.1.2, 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.

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

4.1.4.3 For EGC units of different capacities, the sensitivity to variations in the type of combustion machinery to which they are fitted should be detailed together with sensitivity to the variations in the parameters listed in 4.2.2.1(b). This should be on the basis of testing, or other data as appropriate.

4.1.4.4 The effect of changes of EGC capacity on washwater characteristics should be detailed.

4.1.4.5 All supporting data obtained in accordance with this section, together with the ETM for each capacity unit, should be submitted to the Administration.

4.1.4.6 An SO_2 (ppm)/CO_2 (%) ratio may be used for emission limit value specified in 4.1.2.2, 4.1.2.3 and 4.1.3.

4.2 Survey and certification

4.2.1 Procedures for the certification of an EGC unit

4.2.1.1 In order to meet the requirements of 4.1 either prior to, or after installation onboard, each EGC unit should be certified as meeting the emission limit, (certified value), specified by the manufacturer (e.g., the emission level the unit is capable of achieving on a continuous basis) under the operating conditions and restrictions as given by the EGC Technical Manual (ETM) as approved by the Administration.

4.2.1.2 Determination of the certified value should be in accordance with the provisions of these Guidelines.

4.2.1.3 Each EGC unit meeting the requirements of 4.2.1.1 should be issued by the Administration with a SCC.

4.2.1.4 Application for a SCC should be made by the EGC system manufacturer, shipowner or other party.

4.2.1.5 Subsequent EGC units of the same design and rating as that certified under 4.2.1.1 may be issued with SCC by the Administration without the need for testing in accordance with 4.2.1.1 subject to section 4.1.3 of these Guidelines.

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

4.2.1.7 EGC units which treat only part of the exhaust gas flow of the uptake in which they are fitted should be subject to special consideration by the Administration to ensure that under all defined operating conditions that the overall emission value of the exhaust gas down stream of the system is no more than the certified value.

4.2.2 EGC System Technical Manual (ETM) "Scheme A".

4.2.2.1 Each EGC unit should be supplied with an ETM provided by the Manufacturer. This ETM should, as a minimum, contain the following information:

(a) 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;

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

(i) maximum and, if applicable, minimum mass flow rate of exhaust gas;

(ii) 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 should also be given. In the cases of diesel engines whether the engine is of 2 or 4 stroke cycle;

(iii) maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2);

(iv) exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGC unit in operation;

(v) 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;

(vi) salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and

(vii) other factors concerning the design and operation of the EGC unit relevant to achieving a maximum emission value no higher than the certified value;

(c) any requirements or restrictions 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;

(d) maintenance, service or adjustment requirements in order that the EGCS unit can continue to achieve a maximum emission value no higher than the certified value. The maintenance, servicing and adjustments should be recorded in the EGC Record book;

(e) a verification procedure to be used at surveys to ensure that its performance is maintained and that the unit is used as required (see section 4.4);

(f) through range performance variation in washwater characteristics;

(g) design requirements of the washwater system; and

(h) the SCC.

4.2.2.2 The ETM should be approved by the Administration.

4.2.2.3 The ETM should be retained onboard the ship onto which the EGC unit is fitted. The ETM should be available for surveys as required.

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

4.2.2.5 As an alternative to the maximum emission rate stipulated in Regulation 14(4)(b) a comparable SO_2 (ppm)/CO_2 (%) ratio as prescribed in Figure 1 of the Appendix I measured downstream of EGCS unit may be used.

4.2.3 In service surveys

4.2.3.1 The EGC unit should be subject to survey on installation and at Initial, Annual/Intermediate and Renewals Surveys by the Administration, irrespective of whether or not the ship is in a SECA at the time of Survey.

4.2.3.2 In accordance with MARPOL Annex VI regulation 10, EGC units may also be subject to inspection by PSC when operating within a SECA.

4.2.3.3 Prior to use within a SECA, each EGC unit should be issued with a SECA Compliance Certificate (SCC) by the Administration.

4.2.3.4 The ship's IAPP certificate should be duly endorsed at each survey as required by 4.2.3.1.

4.3 Emission limits

4.3.1 Each EGC unit should be capable of reducing emissions to equal to or less than the certified value at any load point when operated in accordance with the criteria as given within 4.2.2.1(b), as specified in paragraphs 4.3.2 through 4.3.5 of these Guidelines, and as excepted in paragraphs 4.3.7 and 4.3.8.

4.3.2 EGC units fitted to main propulsion diesel engines should meet the requirements of 4.3.1 at all loads between 25-100% of the load range of the engines to which they are fitted.

4.3.3 EGC units fitted to auxiliary diesel engines should meet the requirements of 4.3.1 at all loads between 10-100% of the load range of the engines to which they are fitted.

4.3.4 EGC units fitted to diesel engines which supply power for both main propulsion and auxiliary purposes should meet the requirements of 4.3.3.

4.3.5 EGC units fitted to boilers should meet the requirements of 4.3.1 at all loads between 10-100% of the load range (steaming rates) or, if the turn down ratio is smaller, over the actual load range of the boilers to which they are fitted.

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

4.3.7 For loads below those specified in 4.3.2 to 4.3.5, the EGC unit should continue in operation. In those cases where the fuel oil combustion equipment may be required to operate under idling conditions, the SO_2 emission concentration (ppm) at standardized O_2 concentration (15.0% diesel engines, 3.0% boilers) should not exceed 50 ppm.

4.3.8 Alternatively to the provisions of 4.3.2 to 4.3.5 and 4.3.7, each EGC unit should be capable of reducing emissions to the certified value or below, in SO_2 (ppm)/CO_2 (%) ratio at any load point when operated in accordance with the criteria as given within 4.2.2.1(b) and 4.2.2.4.

4.4 Onboard procedures for demonstrating compliance with emission limit

4.4.1 For each EGC unit, the ETM should contain a verification procedure for use at surveys as required. This procedure should not require specialized equipment or an in-depth knowledge of the system. Where particular devices are required they should be provided and maintained as part of the system. The EGC unit should 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 SCP.

4.4.2 Included in the verification procedure should be all components and operating values or settings which may affect the operation of the EGC unit and its ability to meet the required emission limit.

4.4.3 The verification procedure should be submitted by the EGC system manufacturer and approved by the Administration.

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

4.4.5 The Surveyor should verify that each EGC unit is installed in accordance with the ETM and has an SCC as required.

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

4.4.7 The EGC unit should include means to automatically record when the system is in use. This should automatically record, as a minimum, washwater pressure and flow rate at the EGC unit's inlet connection, pH of washwater at the EGC unit's inlet and outlet connections, 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 should comply with the requirements of sections 7 and 8. In case of a unit consuming chemicals at a known rate as documented in ETM, records of such consumption in the EGC Record Book also serves this purpose.

4.4.8 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_2 (ppm)/CO_2 (%) ratio, is used to verify compliance in conjunction with parameter checks stipulated in 4.4.7. If a continuous exhaust gas monitoring system is fitted, only daily spot checks of the parameters listed in paragraph 4.4.7 would be needed to verify proper operation of the EGC unit.

4.4.9 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 4.4.1, or if this requires specialist equipment or in-depth knowledge, it is recommended that continuous exhaust gas monitoring of each EGC unit be used to assure ship operators of compliance when operating within a SECA and in the event of port State authority inspection.

4.4.10 An EGC Record Book should be maintained by the shipowner recording maintenance and service of the unit. The form of this record should be submitted by the EGC system manufacturer and approved by the Administration. This record book should be available at surveys as required and may be read in conjunction with engine room logbooks and other data as necessary to confirm the correction operation of the EGC unit. Alternatively, this information should be recorded in the vessel's planned maintenance record system as approved by the Administration.

5 SCHEME B – EGC SYSTEM APPROVAL, SURVEY, AND CERTIFICATION USING CONTINUOUS MONITORING OF SOx EMISSIONS

5.1 General

This Scheme should 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 SCP) or below at any load point, including during transient operation and thus compliance with the requirements of regulation 14(4)(b) of MARPOL Annex VI.

5.2 Approval

Compliance demonstrated in service by continuous exhaust gas monitoring. Monitoring system should be approved by the Administration and the results of that monitoring available to the Administration as necessary to demonstrate compliance as required.

5.3 Survey and certification

5.3.1 The monitoring system of the EGC system should be subject to survey on installation and at Initial, Annual/Intermediate and Renewals Surveys by the Administration, irrespective of whether or not the ship is in a SECA at the time of Survey.

5.3.2 In accordance with regulation 10 of MARPOL Annex VI monitoring systems of EGC units may also be subject to inspection by PSC when operating within a SECA.

5.3.3 The ship's IAPP certificate should be duly endorsed at each survey as required by 5.3.1.

5.4 Calculation of emission rate

5.4.1 Exhaust gas composition SO_2 (ppm)/CO_2 (%) ratio method should be measured at an appropriate position after the EGC unit and comply with the requirements of 6.2 and 6.15.

5.4.2 SO_2 (ppm) and CO_2 (%) to be continuously monitored and recorded onto a data recording and processing device at a rate which should not be less than 0.0035 Hz.

5.4.3 If more than one analyser is to be used to determine the SO_2/CO_2 ratio, these should be tuned to have similar sampling and measurement times and the data outputs aligned so that the SO_2/CO_2 ratio is fully representative of the exhaust gas composition.

5.5 Onboard procedures for demonstrating compliance with emission limit

5.5.1 The data recording system should comply with the requirements of sections 7 and 8.

5.5.2 Daily spot checks of the parameters listed in paragraph 4.4.7 are needed to verify proper operation of the EGC unit and should be recorded in the EGC Record book or in the engine room logger system.

5.6 EGC System Technical Manual (ETM) "Scheme B"

5.6.1 Each EGC unit should be supplied with an ETM provided by the Manufacturer. This ETM should, as a minimum, contain the following information:

(a) 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;

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

(i) maximum and, if applicable, minimum mass flow rate of exhaust gas;

(ii) 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 should also be given. In the cases of diesel engines whether the engine is of 2 or 4 stroke cycle;

(iii) maximum and minimum washwater flow rate, inlet pressures and minimum inlet water alkalinity (ISO 9963-1-2);

(iv) exhaust gas inlet temperature ranges and maximum and minimum exhaust gas outlet temperature with the EGC unit in operation;

(v) 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;

(vi) salinity levels or fresh water elements necessary to provide adequate neutralizing agents; and

(vii) other parameters as necessary concerning the operation of the EGC unit;

(c) any requirements or restrictions applicable to the EGC unit or associated equipment;

(d) through range performance variation in washwater characteristics;

(e) design requirements of the washwater system.

5.6.2 The ETM should be approved by the Administration.

5.6.3 The ETM should be retained onboard the ship onto which the EGC unit is fitted. The ETM should be available for surveys as required.

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

6 EMISSION TESTING

6.1 Emission testing should follow the requirements of the NO_x Technical Code, chapter 5, and associated Appendices, except as provided for in these Guidelines.

6.2 CO_2, O_2 and SO_2 should be measured as appropriate. CO_2 O_2 and SO_2 measurement error not to exceed +/- 5 % of the reading or +/- 3,5 % of full scale, whichever is smaller, according to Appendix 3, section 1.5 in the NO_x Technical Code. For concentrations of less than 100ppm, the measurement error should not exceed +/- 4ppm.

6.3 SO_2 should be measured on a dry or wet basis using analysers operating on NDIR or NDUV principles and with additional equipment such as dryers as necessary. Other systems or analysers may be accepted, subject to the approval of the Administration, provided they yield equivalent or better results to those of the equipment referenced above.

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

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

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

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

6.8 Where SO_2 is measured by an in-situ system, the water content in the exhaust gas stream at that point is also to be determined in order to correct the reading to a dry basis value.

6.9 Where the exhaust gas mass flow is to be calculated in accordance with the NOx Technical Code, Appendix 6, the complete combustion case calculations may be used. The exhaust gas mass flow (GEXHW) should be determined in respect of the mass flow into the EGC unit.

6.10 In applying the NOx Technical Code, equation 15, the dry basis SO_2 concentration should be converted to a wet basis value using the dry/wet correction factor applicable to the exhaust gas at entry into the EGC unit (NOx Technical Code, equation 11, CO = 0):

$w = 0.002855$, u = w/exhaust gas density in g/m^3 at 0°C and 101.3 kPa

6.11 The fuel oil as used in the test should be a residual blend product. A representative sample of that fuel should be analysed in order to establish its chemical composition (carbon, hydrogen and sulphur) together with the other parameters as necessary to establish its grade in accordance with the ISO 8217 specification. If necessary to achieve the sulphur levels required

under section 4.1.2, SO_2 gases can be added to the exhaust gas in a manner ensuring equivalent SOx level and homogeneity of SOx in the exhaust gas prior to the EGC system inlet.

6.12 For diesel engines the power should be the uncorrected brake power.

6.13 For boilers the "power" should be determined based on the fuel rate and assumed brake specific fuel consumption of 200 g/kWh.

6.14 In lieu of the testing procedure laid down in 6.9 to 6.10 and 6.12 to 6.13, compliance may be demonstrated by measuring of SO_2 and CO_2 concentration in the exhaust gas down stream of the EGC.

6.15 Should the SO_2 (ppm)/CO_2 (%) ratio method be used:

(a) The conditions stipulated in 6.4 and 6.5 should also apply to the measurement of CO_2 (%) and it is recommended that SO_2 and CO_2 samples should be obtained at the same location.

(b) Measurement of SO_2 and CO_2 should either be carried out above the respective dew points or on a fully dry basis recognizing that the conditions stipulated in 6.6 to 6.8 should also apply to the measurement of CO_2 (%).

(c) The carbon and hydrogen content of the test fuel as stipulated in 6.11 need not be determined.

(d) SO_2 and CO_2 measurement technology should be as given under 6.3.

7 DATA RECORDING AND PROCESSING DEVICE

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

7.2 The recording and processing device should record the data required by sections 4.4.7, 5.4.2, and 10.3 against UTC and ships position by a Global Navigational Satellite System (GNSS).

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

7.4 Data should be retained for a period of not less than 18 months from the date of recording. If the unit is changed over that period, the shipowner should ensure that the required data is retained onboard and available as required.

7.5 The device should be capable of downloading a copy of the recorded data and reports in a readily useable format. Such copy of the data and reports should be available to the Administration or port State authority as requested.

8 ONBOARD MONITORING MANUAL (OMM)

8.1 An OMM should be prepared to cover EGC unit for each item of fuel oil combustion equipment, which should be identified, for which compliance is to be demonstrated.

8.2 The OMM should, as a minimum, include:

(a) the sensors to be used in evaluating EGC system performance and washwater monitoring, their service, maintenance and calibration requirements;

(b) 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;

(c) the analysers to be used, their service, maintenance, and calibration requirements;

(d) analyser zero and span check procedures; and

(e) other information or data relevant to the correct functioning of the monitoring systems or its use in demonstrating compliance.

8.3 The OMM should specify how the monitoring is to be surveyed.

8.4 The OMM should be approved by the Administration.

9 SHIP COMPLIANCE

9.1 SECA Compliance Plan (SCP)

9.1.1 For all ships which are to use an EGC unit, in part or in total, in order to comply with the requirements of regulation 14(4) of MARPOL Annex VI there should be a SCP for the ship, approved by the Administration.

9.1.2 The SCP should list each item of fuel oil combustion equipment which is to meet the requirements for operating in a SECA.

9.1.3 Under Scheme A, the SCP should present how continuous monitoring data will demonstrate that the parameters in paragraph 4.4.7 are maintained within the manufacturer's recommended specifications. Under Scheme B, this would be demonstrated using daily recordings of key parameters.

9.1.4 Under Scheme B, the SCP should present how continuous exhaust gas emissions monitoring will demonstrate that the ship total SO_2 (ppm)/CO_2 (%) ratio is comparable to regulation 14(4)(b) or below as prescribed in Figure 1 of Appendix I. Under Scheme A, this would be demonstrated using daily exhaust gas emission recordings.

9.1.5 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 should be listed in the SCP. For these fuel oil combustion units which are not to be fitted with EGC units, compliance may be achieved by means of regulation 14(4)(a) of MARPOL Annex VI, while operating within a SECA. Alternatively, compliance may be achieved based on total ship emissions as described in paragraphs 9.1.7 and 9.1.8.

9.1.6 Ship construction requirements generally require that each fuel oil combustion unit should have its own exhaust gas system venting to the atmosphere. Therefore compliance by the ship may be demonstrated by each item of fuel oil combustion equipment meeting the requirements of either Scheme A or Scheme B. Alternatively, compliance may be demonstrated on the basis of total emissions generated by the ship as noted in paragraphs 9.1.7 and 9.1.8.

9.1.7 If each fuel oil combustion unit meets the requirements of either regulation 14(4)(a) or 14(4)(b) of MARPOL Annex VI, the ship is considered to be in compliance with the requirements.

9.1.8.1 Recognizing that the limit given in regulation 14(4)(b) of MARPOL Annex VI is for the ship, not each individual item of combustion equipment, the shipowner should have the opportunity to balance performance which considerably exceeds that stipulated in regulation 14(4)(b) or the comparable SO_2 (ppm)/CO_2 (%) ratio as prescribed in Figure 1 of Appendix I against that of equipment, potentially not fitted with EGC units, which does not meet that requirement. These cases should be subject to special consideration by the administration. In particular the SCP should detail how the actual emissions from each fuel oil combustion unit are to be aggregated together to obtain an overall, real time, emission value for the ship which does not exceed that stipulated in regulation 14(4)(b) or the comparable SO_2 (ppm)/CO_2 (%) ratio as prescribed in Figure 1 of Appendix I.

9.1.8.2 Since the emission value in regulation 14(4)(b) of MARPOL Annex VI is an alternative to that given in regulation 14(4)(a) of MARPOL Annex VI, not an equivalent, compliance in excess of that required by means of regulation 14(4)(a) of MARPOL Annex VI, in respect of fuel oil combustion units, such as given in section 9.1.8.1, should only be set against the requirements of regulation 14(4)(b) of MARPOL Annex VI where it can be clearly documented as to the actual sulphur content of the fuel oil being used at any time together with the requirement that the specific fuel consumption rate (g fuel/kWh) of that equipment is capable of determination on a real time basis (calibration requirements of such equipment to comply with those as given in the NOx Technical Code).

9.1.9 At no time during operation in a SECA should the total ship emissions, as described in paragraph 9.1.5, exceed that stipulated in regulation 14(4)(b) or exceed the comparable SO_2 (ppm)/CO_2 (%) ratio as prescribed in Figure 1 of Appendix I. Shipowners are advised to consider worst case operating scenarios, such as manoeuvring or high power operation, in their SOx control strategies.

9.2 Demonstration of Compliance

9.2.1 Scheme A

9.2.1.1 The SCP should refer to, not reproduce, the ETM, EGC Record Book or Engine Room logger system and OMM as specified under Scheme A. It should be noted that as an alternative, the maintenance records may be recorded in the ship's Planned Maintenance Record System, as allowed by the Administration.

9.2.1.2 For all fuel oil combustion equipment listed under 9.1.1, details should be provided demonstrating that the rating and restrictions for the EGC unit as approved, 4.2.2.1(b), are complied with.

9.2.1.3 Required parameters should be monitored and recorded as required under 4.4.7 while within a SECA in order to demonstrate compliance.

9.2.2 Scheme B

9.2.2.1 The SCP should refer to, not reproduce, the ETM, EGC Record Book or Engine Room logger system and OMM as specified under Scheme B.

10 WASHWATER

10.1 Washwater discharge criteria[1]

10.1.1 When the EGC System is operated in a ports, harbours, or estuaries, the discharge water should comply with the following limits:

10.1.2 pH criteria

10.1.2.1 The washwater pH should comply with one of the following requirements which should be recorded in the ETM:

(i) The discharge washwater should have a pH of no less than 6.5 at the overboard discharge with the exception that during manoeuvring and transit, the maximum difference between inlet and outlet of 2 pH units is allowed.

(ii) During commissioning of the unit(s) after installation, the discharged washwater plume should be measured externally from the ship (at rest in harbour) and the discharge pH at the ship's overboard pH monitoring point will be recorded when the plume at 4 metres from the discharge point equals or is above pH 6.5. The discharged pH to achieve a minimum pH units of 6.5 will become the overboard pH discharge limit recorded in the ETM.

[1] The washwater discharge criteria should be revised in the future as more data becomes available on the contents of the discharge and its effects, taking into account any advice given by GESAMP.

10.1.3 PAHs (Polycyclic Aromatic Hydrocarbons)

The washwater PAH should comply with the following requirements. The appropriate limit should be recorded in the ETM.

10.1.3.1 The maximum continuous PAH concentration in the washwater should not be greater than 50 µg/L PAH_{phe} (phenanthrene equivalance) above the inlet water PAH concentration. For the purposes of this criteria, the PAH concentration in the washwater should be measured downstream of the water treatment equipment, but upstream of any washwater dilution or other reactant dosing unit, if used, prior to discharge.

10.1.3.2 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. This limit would have to be adjusted upward for lower washwater flow rates per MWh, and vice-versa, according to the table below.

Flow Rate (t/MWh)	**Discharge Concentration Limit (µg/L PAH_{phe} equivalents)**	**Measurement Technology**
0 - 1	2250	Ultraviolet Light
2.5	900	– ” –
5	450	Fluorescence
11.25	200	– ” –
22.5	100	– ” –
45	50	– ” –
90	25	– ” –

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

10.1.4 Turbidity/Suspended Particle Matter

The washwater turbidity should comply with the following requirements. The limit should be recorded in the ETM.

10.1.4.1 The washwater treatment system should be designed to minimize suspended particulate matter, including heavy metals and ash.

10.1.4.2 The maximum continuous turbidity in washwater should not be greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, above the inlet water turbidity. However during periods of high inlet turbidity the precision of the measurement device and the time lapse between inlet measurement and outlet measurement are such that the use of a difference limit is unreliable. Therefore all turbidity difference readings should be a rolling average over a 15-minute period to a maximum of 25 FNU. For the purposes of this criteria the turbidity in the washwater should be measured downstream of the water treatment equipment but upstream of washwater dilution (or other reactant dosing) prior to discharge.

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

10.1.5 Nitrates

10.1.5.1 The washwater treatment system should prevent the discharge of nitrates beyond that associated with a 12% removal of NOx from the exhaust, or beyond 60 mg/l normalized for washwater discharge rate of 45 tons/MWh whichever is greater.

10.1.5.2 All systems should be tested for nitrates in the discharge water. If typical nitrate amounts are above 80% of the upper limit, it should be recorded in the ETM.

10.1.6 Washwater additives and other substances

10.1.6.1 An assessment of the washwater is required for those EGC technologies which make use of active substances, 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 should be established.

10.2 Washwater monitoring

10.2.1 pH, oil content (as measured by PAH levels), and turbidity should be continuously monitored and recorded as recommended in section 1 of these guidelines. The monitoring equipment should also meet the performance criteria described below:

pH

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

PAH

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

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

Turbidity

10.2.5 The turbidity monitoring equipment should meet requirements defined in ISO 7027:1999 or USEPA 180.1.

10.3 Washwater monitoring data recording

10.3.1 The data recording system should comply with the requirements of sections 7 and 8 and should continuously record pH, PAH and Turbidity as specified in the washwater criteria.

10.4 Washwater residue

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

10.4.2 Each ship fitted with an EGC unit should 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 as approved by the Administration.

APPENDIX I

SO_2 OVER CO_2 MONITORING METHOD

1 Correspondence between 65 ([1]ppm/%) SO_2/CO_2 and 1.5% sulphur in fuel is demonstrated by first calculating the mass ratio of fuel sulphur to fuel carbon, which is tabulated in Table 1 for various fuels and fuel sulphur contents; including 1.5% sulphur for both distillate and residual fuels. These ratios were used to solve for the corresponding SO_2 and CO_2 concentrations in exhaust, which are tabulated in Table 2. 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_2 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_2 concentration changes, but the SO_2/CO_2 ratio does not. This indicates that the SO_2/CO_2 ratio is independent of fuel-to-air ratios. Therefore, SO_2/CO_2 ratio can be used robustly at any point of operation, including operation where no brake power is produced.

Note that the SO_2/CO_2 ratio varies slightly from distillate to residual fuel. 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_2/CO_2 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% S, the difference in S/C ratios for distillate and residual fuel is less than 5.0%.

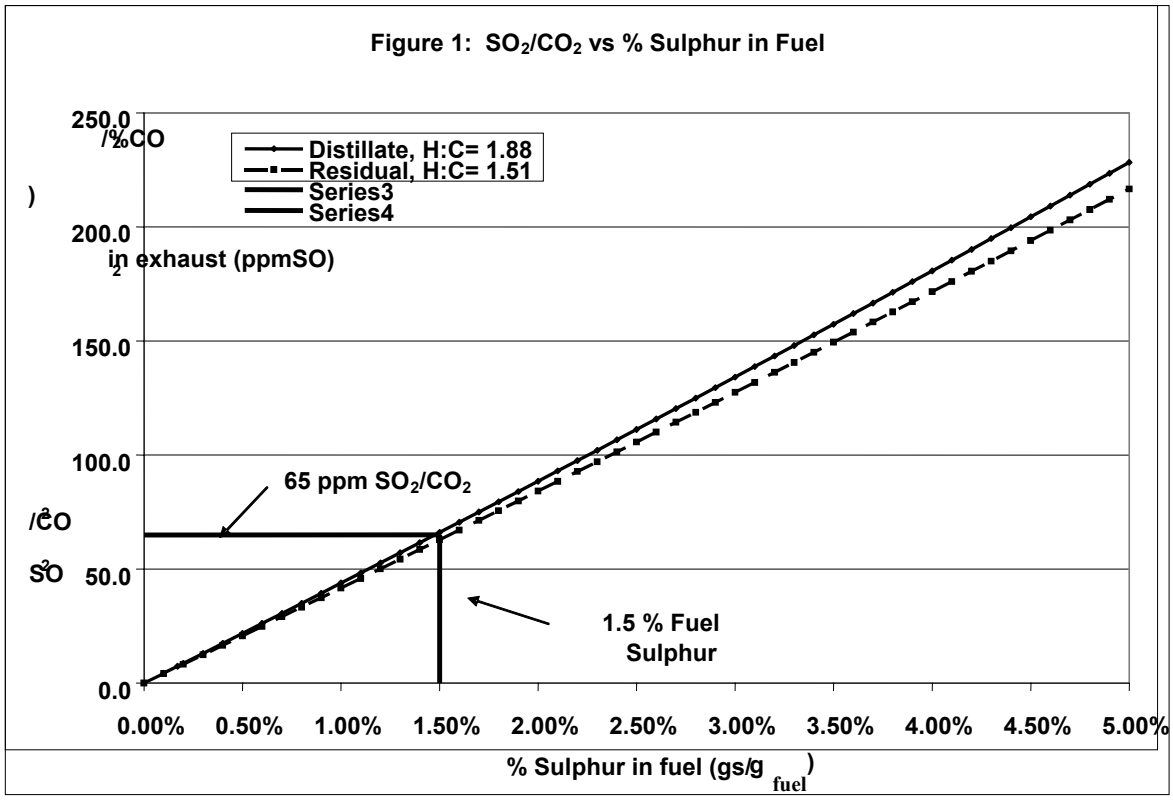
Table 1: Fuel properties for marine distillate and residual fuel

	Carbon	Hydrogen	Sulphur	Other	H:C	Fuel S/C
	g/g	g/g	g/g	g/g	mol/mol	g/g
Distillate*	86.20%	13.60%	0.17%	0.03%	1.880	0.00197
Residual*	86.10%	10.90%	2.70%	0.30%	1.509	0.03136
Distillate 1.5% S	85.05%	13.42%	1.50%	0.03%	1.880	**0.01764**
Residual 1.5% S	87.17%	11.03%	1.50%	0.30%	1.509	**0.01721**

*Based on properties in the IMO NO_x Monitoring Guidelines, MEPC.103(49)

Table 2: Emissions calculations corresponding to 1.5 % fuel sulphur

	CO_2	SO_2	Exh SO_2/CO_2	Exh S/C
	%	[1]ppm	[1]ppm/%	g/g
Distillate 0.17% S	8	59.1	7.4	0.00197
Residual 2.70% S	8	939.7	117.5	0.03136
Distillate 1.5% S	8	528.5	**66.1**	**0.01764**
Residual 1.5% S	8	515.7	**64.5**	**0.01721**
Distillate 1.5% S	0.5	33.0	**66.1**	**0.01764**
Residual 1.5% S	0.5	32.2	**64.5**	**0.01721**



2 Correspondence between 65 ([1]ppm/%) / CO_2 and 6.0 g/kWh is demonstrated by showing that their S/C ratios are similar. This requires the additional assumption of a brake-specific fuel consumption value of 200 g/kWh. This is an appropriate average for marine diesel engines. The calculation is as follows:

$$S/C_{fuel} = \frac{\text{brake-specific } SO_2 * \left(MW_S / MW_{SO2}\right)}{BSFC * \left(\%\text{ carbon in fuel} / 100\right)}$$

brake-specific $SO_2 = 6.0$ g/kW-hr

$MW_S = 32.065$ g/mol

$MW_{SO2} = 64.064$ g/mol

BSFC = 200 g/kW-hr

% carbon in 1.5% S fuel (from Table 1) = 85.05% (distillate) & 87.17% residual

$$S/C_{residual\ fuel} = \frac{6.0 * \left(32.065 / 64.064\right)}{200 * \left(87.17\% / 100\right)}$$

$S/C_{residual\ fuel} = 0.01723$

$$S/C_{distillate\ fuel} = \frac{6.0 * \left(32.065 / 64.064\right)}{200 * \left(85.05\% / 100\right)}$$

$S/C_{distillate\ fuel} = 0.01765$

Note that the S/C mass ratios calculated above, based on 6.0 g/kWh and 200 g/kWh BSFC, are both within 0.10% of the S/C mass ratios in the emissions table (Table 2). Therefore, 65 [1]ppm/CO_2 corresponds well to 6.0 g/kWh in regulation 14(4)(b).

3 Thus, the working formulas are as follows:

For complete combustion = $\dfrac{SO_2\ (ppm^*)}{CO_2\ (\%^*)} \leq 65$

For incomplete combustion = $\dfrac{SO_2\ (ppm^*)}{CO_2(\%^*) + (CO\ (ppm^*)/10000) + (THC\ (ppm^*)/10000)} \leq 65$

* Note: gas concentrations must be sampled or converted to the same residual water content (e.g., fully wet, fully dry).

4 The following is the basis of using the 65 ([1]ppm/%) SO_2/CO_2 as the limit for determining compliance with regulation 14:

(a) This limit can be used to determine compliance from fuel oil burners that do not produce mechanical power.

(b) This limit can be used to determine compliance at any power output, including idle.

(c) This limit only requires two gas concentration measurements at one sampling location.

(d) There is no need to measure any engine parameters such as engine speed, engine torque, engine exhaust flow, or engine fuel flow.

(e) 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.

(f) This limit completely decouples the thermal efficiency of the fuel oil combustion unit from the EGCS-SO_x unit.

(g) No fuel properties need to be known.

(h) Because only two measurements are made at a single location, transient engine or EGCS-SO_x unit effects can be minimized by aligning signals from just these two analysers. (Note that the most appropriate points to align are the points where each analyser responds to a step change in emissions at the sample probe by 50% of the steady-state value).

(i) This limit is independent of the amount of exhaust gas dilution. Dilution may occur due to evaporation of water in an EGCS-SO_x unit, and as part of an exhaust sampler's preconditioning system.

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[1] 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), but ppm is used in order to be consistent with units in the NO_x Technical Code.

APPENDIX II

WASHWATER DATA COLLECTION

Background

The washwater discharge criteria are intended to act as initial guidance for implementing EGC system designs. The criteria should be revised in the future as more data becomes available on the contents of the discharge and its effects, taking into account any advice given by GESAMP.

To this end, ships in conjunction with the EGC manufacturer are requested to sample and analyse samples of:

- inlet water (for background);
- 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 should be undertaken by laboratories using EPA or ISO test procedures for the following parameters:

- pH
- PAH and oil (detailed GC-MS analysis)
- 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 samples, information on washwater discharge flow rates, dilution of discharge, if applicable, and engine power should be included as well as specifications of the fuel used from the BDN as a minimum.

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

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