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MARITIME ENVIRONMENT PROTECTION COMMITTEE
82nd session
Agenda item 5

AIR POLLUTION PREVENTION

Comments on document MEPC 78/9/3 on emission factors for environmental risk assessment of the discharge water from exhaust gas cleaning systems

Submitted by IBIA

SUMMARY

Executive summary:	This document comments on document MEPC 78/9/3 (Germany) and, based on a detailed evaluation of the data set used, concludes that it does not appear to be a suitable and sufficient basis for development of representative emission factors for environmental risk assessment of the discharge water from exhaust gas cleaning systems (EGCS).
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 35
Related documents:	Resolution MEPC.340(77); MEPC.1/Circ.899; MEPC 73/INF.5; MEPC 77/WP.8; MEPC 78/9/3, MEPC 78/17; MEPC 79/5/1, MEPC 79/15; PPR 9/INF.16 and PPR 11/7/5

Introduction

1 This document comments on document MEPC 78/9/3 (Germany) concerning "Unified and representative emission factors for environmental risk assessment of the discharge water from exhaust gas cleaning systems".

Background

2 MEPC 78, having considered the report of PPR 9 and relevant documents submitted to that session, approved MEPC.1/Circ.899 on *2022 Guidelines for risk and impact assessments of the discharge water from exhaust gas cleaning systems*, which provides information on recommended methodology for risk and impact assessments that Member States should follow when considering local or regional regulations to protect sensitive waters and the environment from EGCS discharge water that complies with the MARPOL Convention (MEPC 78/17, paragraph 5.16 and paragraphs 1.1 to 1.3 of MEPC.1/Circ.899).

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3 In relation to this output, the Committee also recalled the course of action it had agreed to during its consideration and approval of the PPR Sub-Committee's biennial status report to consider reinstating output 1.23 in the provisional agenda of a future session of the PPR Sub-Committee (i.e. after PPR 10), subject to further proposals to MEPC, including those relating to part 4 (database of substances) of the scope of work of the output, by interested Member States and international organizations (MEPC 78/17, paragraph 14.14.3).

4 Output 1.23, part 4 refers to the database of priority hazardous substances to be developed by the Organization that should be used for environmental risk assessment (ERA) including unified and representative emission factors (mg/MWh) based on the data for discharge water concentration and flow rate collected by the Organization. The database is to be placed within the IMO GISIS under a separate new item titled "Chemicals in EGCS Discharge Water" (MEPC.1/Circ.899, paragraphs 5.1.2.1 to 5.1.2.3).

5 MEPC 79, having considered various documents, agreed to refer documents including document MEPC 79/5/1 (CESA) on representative emissions factors to PPR 11 and instructed the PPR Sub-Committee to consider them further in conjunction with document MEPC 78/9/3, with a view to advising the Committee accordingly (MEPC 79/15, paragraph 5.13).

6 The PPR 11 Working Group on Prevention of Air Pollution from Ships considered how to advance the development of unified and representative emission factors for use in the environmental risk assessment of EGCS, taking into account documents MEPC 78/9/3, MEPC 79/5/1, and PPR 11/7/5 (ICS and CLIA), with a view to advising the PPR Sub-Committee. Several delegations stressed the need to assess the robustness of the data and methodology used for the development of representative emission factors.

Commentary

7 This document examines in greater detail previous comments related to the data set and methods used in document MEPC 78/9/3 to develop emission factors for EGCS discharge water and looks specifically at: the source data used; the standard methods for sampling and chemical analysis; the management of detection limits and the determination of flow rates in relation to the calculation of emission factors (mg/MWh).

Source data

8 Document MEPC 78/9/3 proposes that the emission factors for metals, polycyclic aromatic hydrocarbons (PAH) and nutrients as listed in table 17 of the annex to document PPR 9/INF.16 (Sweden) are used as unified and representative emission factors (mg/MWh), rather than those developed from discharge water substance concentrations and flow rates collected locally from ships or by the Organization, and that the proposed emission factors should be included as an appendix to the *Guidelines for risk and impact assessments of the discharge water from exhaust gas cleaning systems*.

9 The basis for the proposal in document MEPC 78/9/3 is that the emission factors reported in PPR 9/INF.16 are based on "an extensive literature review conducted by the Chalmers University of Technology, averaging a total of 48 measurements from 12 different EGCS studies to obtain average emission factors of substances found in the discharge water from EGCS: metals, PAH and nutrients" (MEPC 78/9/3, paragraph 7).

10 Comments in this document are based on an examination of the source data set (by file properties created in 2019) from the Chalmers University literature review, which was published in 2020. The data set has been iterated for use in a number of other studies including the European Union's EMERGE project*.

11 Selection of the sample class "*Open loop scrubber discharge*" in the source data set confirms that it has been derived from a literature review of 15 studies ranging in date from 1993 to 2020. References for 13 of the 15 studies are provided, two are unpublished. This data set is based on samples taken between 1993, when marine scrubbing technology was at a prototype stage, and 2018, with the bulk of samples including those in document MEPC 73/INF.5 (CESA) being taken on ships of early EGCS adopters (e.g. ro-pax and ro-ro ship operators) operating in North-West Europe and the Baltic Sea.

12 The emission factor calculation is based on a total of 87 sample "data points", four of which are listed as median or average values of a number of sample analyses and two of which are listed as "*Scrubber outlet before cleaning*" (a review of the reference document confirms these samples were not taken at the overboard discharge).

13 The following is used to calculate substance emission factors:

$EF_{substance}$ *(mg/MWh) = Average substance concentration in open loop discharge water (µg/l)* **.** *Average specific discharge flow rate* (m^3*/MWh)*

where,

.1 average substance concentration is simply calculated from the source data set by the addition of each of the reported concentrations of that substance in an open loop discharge divided by the number of concentrations recorded; and

.2 an average specific discharge flow rate of 90 m^3/MWh. (The method of calculation for the average specific discharge flow rate is discussed later in this document).

14 The number of sample data points used to calculate average substance concentration and thus the emission factor varies from a minimum of just 2 (metal – selenium) and 11 (nutrient – NH_4) to maximums of 64 (PAHs – phenanthrene, benz(a)anthracene and benzo(a)pyrene) and 70 (copper and zinc). Small data sets can result in unrepresentative average values. Seven of the 15 emission factors for metals are based on average substance concentrations derived from 25 or less sample data points and 6 of the 15 emission factors are based on 10 or less sample data points.

Standard methods for sampling and chemical laboratory analysis

15 The test methods in the source data set and the use of non-standard test methods and sampling protocols, rather than those recommended in the *2021 Guidelines for exhaust gas cleaning systems* (2021 EGCS Guidelines) (resolution MEPC.340(77)), indicate potential for a lack of data quality and comparability.

16 MEPC.1/Circ.899, paragraph 5.1.2.2.2, reads as follows: "If the Member States propose to use their original Emission Factors with a scientific reasoning based on their original measurement of EGCS discharge water, all the measurements should be analysed in accordance with the 2021 EGCS Guidelines."

* Available to download in Microsoft Excel format under the title *Supplementary information to EMERGE Deliverable 2.1* at https://research.chalmers.se/en/publication/527206 and *EMERGE Deliverable 2.4* at: EMERGE deliverable 2.4. Multivariate prediction of scrubber water toxicity (chalmers.se)

17 It is well known that different sample preparation and analysis methods can result in different levels of target substance recovery from a sample of liquid and any particles within it and the concentration of substance finally reported. Appendix 3 of the 2021 EGCS Guidelines therefore recommends in paragraph 2.4.1 that specific ISO and EPA standard test methods be used in order to "ensure comparability of laboratory results".

18 The 2021 EGCS Guidelines also provide important information on sampling procedures, which are highly relative when collecting samples for analyses of substances at parts per billion concentrations. Examination of the thirteen published studies referenced by Chalmers University in document PPR 9/INF.16 shows that only three studies provide an in-depth description of the sampling process and all studies were undertaken before the 2021 EGCS Guidelines were adopted.

19 Of the thirteen published studies, eight do not give the test standard (ISO or EPA), and, where discussed only give a general description of the test methodologies. Of the remaining five, one study (1993) uses a now withdrawn national standard test method. Three studies use a mix of both recommended ISO or EPA standard test methods and "in-house" or modified laboratory methods. One study of selected dissolved metals uses the standard test method recommended in the 2021 EGCS Guidelines.

20 A simple illustration of the potential for lack of result comparability is that it is not known if each concentration value used in the average calculations of metals represents results of a total metals analysis, i.e. dissolved plus particle-bound metals or just metals dissolved in the liquid sample.

Management of detection limits

21 Further examination of samples with a concentration below the limit of detectability/quantification also illustrates the likely incomparability of results from different test methods. This is particularly relevant for around one third of both metal and PAH species, where a significant proportion of samples were reported to have a concentration below the limit of detectability/quantification. As is typical scientific practice, such samples in the Chalmers University study are considered to have a concentration of half the limit of detectability and these concentrations are then used in the calculation of the overall concentration average. However, this practice is dependent on the use of similar laboratory detection limits across the data set for each substance tested and should be as close as possible to current laboratory equipment sensitivities and detection limits. It is highlighted in the source data set where this technique has been applied, enabling the extent of non-detectability and its effects to be reviewed.

22 Emission factors for 15 metals and 16 PAH species are proposed in document MEPC 78/9/3. However, of those, concentrations of five metals and five PAH species are below the limit of detectability in over 50% of the samples.

23 Taking arsenic as an example, the overall average concentration is calculated from 62 sample data points. Of these, 42 (68%) are below the limit of detectability and so have the 50% limit of detectability value for the test method applied. The resulting average is 6.9 µg/l (parts per billion), as the limit of detectability from the different labs used varies between 0.1 and 20 µ/l (i.e. by a factor of 200) depending on the study and individual data set.

24 Similarly taking the PAH species benzo(a)pyrene as an example, the overall average concentration is calculated from 64 sample data points, of which 34 (53%) have concentrations below the limit of detectability and so have the 50% limit of detectability value for the test method applied. The resulting average is 0.054 µ/l (parts per billion), as the limit of detectability for the different sample sources varies between 0.00017 and 0.1 µ/l (i.e. by a factor of ~600) depending on the study and individual data set.

25 When non-detectable concentrations are replaced with 50% as the detectable limit, results that have high limits of detectability artificially increase the average across all samples. As stated above, two samples with a non-detect result could vary by a factor of 600.

Determining specific discharge flow rate

26 An average specific discharge flow rate of 90 m^3/MWh is applied in the emission factor calculation of document MEPC 78/9/3. This average is simply calculated from 48 sample data points in a similar way to average substance concentration by the addition of the recorded specific discharge flow rates and dividing by 48.

27 Only two studies (42 of the 48 sample data points) include discharge flow rate and engine power data at the time of sampling. Discharge flow rate and/or engine power data is not recorded for 45 sample data points (51%). However, for the calculation of the specific discharge flow rate, both parameters are needed for a sample to be qualified for use in a representative database as follows:

$$\textit{Specific discharge flow rate } (m^3/MWh) = \frac{\textit{EGCS overboard discharge flow rate } (m^3/h)}{\textit{Engine power } (MW)}$$

28 As the specific discharge flow rate has a directly proportional effect on the calculation of every emission factor, the following questions the use of a single flow rate value (90 m^3/MWh) for all samples, and also provides comments on determining a representative flow rate value.

29 It is generally considered that a nominal specific flow rate of 45 m^3/MWh is a suitable proxy applicable to open loop seawater scrubbing and as such is used in the 2021 EGCS Guidelines. An examination of the distribution of the 48 specific discharge flow rates used to calculate the average 90 m^3/MWh for the emission factor calculations of document MEPC 78/9/3 shows that 26 sample data points are in the range 37 to 75 m^3/MWh, a further 13 are in the range 75 to 113 m^3/MWh and the remaining nine are above 145 m^3/MWh.

30 Of the 48 sample data points with specific discharge flow rates, 34 were sourced from the study report on analyses of water samples from exhaust gas cleaning systems provided in document MEPC 73/INF.5, which is helpful as this study provides both discharge flow rate (m^3/h) and engine power (MW) together with ship codes and sampling location. However, a closer examination of this data, which was recorded between 2015 and 2017, shows that the high specific discharge rates were typically found when ships were operating and manoeuvring at low engine powers near ports and anchorages.

31 In the last ten years, improvements in EGCS scrubbing efficiency and in seawater flow control have been made, for example using variable frequency drive pumps, which has resulted in less seawater needed and less energy consumed.

32 Standard sampling protocols require a higher engine load to achieve a representative sample concentration and flow rate. Higher specific discharge flow rates at low engine loads may heavily skew the average value in a relatively small data set of 48. For example, if the specific rates at or above 150 m^3/MWh are disregarded, the average reduces to 74 m^3/MWh. All of these sampling events were at engine powers below the minimum of 50% now recommended in the 2021 EGCS Guidelines (appendix 3, paragraph 2.2.1) and as recommended by EPA and ISO sampling protocols. If all the specific rates below 50% engine load were removed, the result would be an average of 62 m^3/MWh (significantly less than the 90 m^3/MWh assumed in MEPC 78/9/3).

Summary and conclusion

33 A detailed review of the source data for document PPR 9/INF.16 suggests the emissions factors, calculated from an average substance concentration and specific discharge flow rate of 90 m^3/MWh proposed in document MEPC 78/9/3, are not representative for the following reasons:

.1 **Source data**: the reference studies largely involve early adopters of marine EGCS technology and may not be representative of current systems, and in some cases, only a very few sample data points have been used to calculate the emission factors;

.2 **Standard methods**: it cannot be confirmed that source data of substance concentrations are comparable because test methods provided in the 2021 EGCS Guidelines have not been reported or followed;

.3 **Detection limits**: the lack of comparability is illustrated by the wide-ranging limits of detectability across the data set, which vary from laboratory to laboratory by a factor of up to 600 for a single substance. Furthermore, a number of substances are undetected in a large proportion of samples with the resulting potential for significant inaccuracy in the average concentrations and thus emission factors, as a concentration of 50% of the wide range of limits of detectability for each substance is applied; and

.4 **Flow rates**: the specific open loop discharge flow rate of 90 m^3/MWh is skewed to an overly high value in a relatively small data subset, as samples were taken during ship manoeuvring at engine powers well below that recommended in the 2021 EGCS Guidelines. Furthermore, marine EGCS technologies have continued to mature since early installations and advances in energy efficiency measures for seawater pumping systems should be taken into account.

Recommendations

34 Taking the above points into consideration, an appropriate basis for the development of representative emission factors would be a large data set of samples, gathered globally under an accepted standard protocol, with engine load range levels above 50%, and analysed at laboratories with equipment providing common low detection levels. All relevant operational data used in the calculation of the Emission Factor should be included, e.g. ship, location, time/date, engine load and discharge water flow rates.

Action requested of the Committee

35 The Committee is invited to consider the information provided in this document and take action as appropriate.