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AIR POLLUTION PREVENTION

Puget Sound Exhaust Gas Cleaning System (EGCS) washwater ecological risk assessment

Submitted by CLIA

SUMMARY

Executive summary:	This document provides information on a risk assessment of open loop exhaust gas cleaning system (EGCS) washwater discharges from cruise ships within the Puget Sound region of the United States as presented by the study team based on the recommended methodology provided in the *2022 Guidelines for risk and impact assessments of the discharge water from exhaust gas cleaning systems* (MEPC.1/Circ.899).
Strategic direction, if applicable:	1
Output:	1.23
Action to be taken:	Paragraph 15
Related documents:	PPR 7/INF.23; PPR 9/10/1; MEPC 74/14/8, MEPC 74/INF.24; MEPC 76/9/2 and MEPC 76/INF.33

Introduction

1 The Marine Environment Protection Committee at its seventy-eighth session approved the *2022 Guidelines for risk and impact assessments of the discharge water from exhaust gas cleaning systems* (MEPC.1/Circ.899). The guidelines provide a recommended methodology for determining environmental risk and impacts from Exhaust Gas Cleaning System (EGCS) discharge water. The Guidelines were intended to provide a unified scientific approach for risk assessment to allow for an evidentiary based decision process and justification prior to the introduction of local restrictions on the use of EGCS.

2 With consideration of the recommendation for Member States to conduct environmental risk assessments in accordance with the guidelines and local and regional conditions, a study was conducted to evaluate ecological effects from the use of EGCS by cruise ships at berth and in transit through Puget Sound to and from the Port of Seattle of the United States. The study was designed to use state-of-the-science methods to evaluate potential environmental risks to Puget Sound from the operation of open-loop EGCS in cruise

ships. The study employed a combination of analytical determinations modelling both washwater toxicity and post-discharge environmental concentrations, and a comparison of the toxicity model predictions to empirical results from Whole Effluent Toxicity (WET) bioassay testing methods.

3 The study was designed and conducted by the study team in consultation with the Cruise Lines International Association (CLIA) and included engagement with Washington State Department of Ecology and the Port of Seattle. As of submission, the study has completed peer review by an advisory panel, however the Washington State Department of Ecology and Port of Seattle have not completed their technical review. The report of the study, as presented by the study team, is available at https://ir.library.oregonstate.edu/concern/technical_reports/f4752r24m.

Study team and study phases

4 The study team was comprised of experts in the fields of ecotoxicology, ecological risk assessment, and environmental fate and effects modeling, and had oversight of all phases of the study. The study phases included:

.1 sample collection from five different ships (six unique diesel generators) during six Puget Sound transits, including samples from three locations: seawater inlet (background), post-EGCS tower, and overboard discharge locations;

.2 empirical testing, including:

.1 analytical chemistry for 11 metals, 60 PAH's and other parameters; and

.2 Whole Effluent Toxicity Testing (WET), conducted on four different species.

.3 modelling, including:

.1 a summation-based model, the Target Lipid Model (TLM)[1] used for evaluating potential PAH toxicity from chemical mixtures (60 PAHs); and

.2 modelling for predicted environmental concentrations, using both the MAMPEC[2] and CORMIX[3] models.

.4 risk assessment, determined from predicted environmental concentrations (PEC) compared with predicted no effect concentrations (PNEC).

[1] Target Lipid Model (TLM) is a modelling framework for predicting aquatic toxicity in PAH-containing waters.

[2] MAMPEC (Marine Antifoulant Model to Predict Environmental Concentrations, or PEC's) is an integrated 2D hydrodynamical and chemical fate model developed by Deltares.

[3] CORMIX (Cornell Mixing Zone Model) is a USEPA-supported mixing zone model and decision support system for environmental assessments of continuous point source discharges and has been used previously by WDOE.

Study results

5 Analytical determinations (metals, PAHs, pH, and nitrites/nitrates) were conducted on all seawater samples. Total metals were also measured in the fuel feeding the diesel generator set associated with each EGCS line during the sampling. Measurable concentrations of some metals (e.g. chromium, lead, nickel, and vanadium) were elevated over background concentrations in samples collected after the EGCS tower (i.e. post-EGCS tower and overboard discharge waters), and were also present in the fuel samples. Chromium and lead concentrations were below the United States Environment Protection Agency's (United States EPA) Ambient Water Quality Criteria, the Washington State water quality standards, and also the European predicted no-effect concentrations (PNEC) in the overboard discharge samples. Measured nickel concentrations were lower than both the United States EPA Nickel Criterion and the Washington State standards but were slightly higher than the PNEC in the overboard discharge samples. No United States EPA criterion or Washington State standard exists for vanadium, which also slightly exceeded the PNEC. As nickel and vanadium exceeded the PNEC in the overboard discharge samples, these metals were further considered during modelling activities.

6 Other parameters: nitrites and nitrates were detected at the inlet at low levels but showed very limited change after the EGCS tower. pH levels at discharge were in compliance with regulatory mandated concentrations for United States waters (i.e., >6.0).

7 The Target Lipid Model (TLM) was used to predict the potential toxicity of polynuclear aromatic hydrocarbon (PAH) components in EGCS overboard discharged waters; measurable concentrations of PAHs were noted in overboard discharge water samples. For this study, 60 individual PAHs were analysed, and these results were used to calculate estimated toxic units[4] (TU) for each sample. The TLM predicted that buffered discharge water would be slightly acutely toxic to the most sensitive organisms in all but three samples, while chronic toxicity was predicted in all samples collected.

8 Whole Effluent Toxicity (WET) tests performed for this study were based on state-of-the-science United States EPA and WDOE methods for short-term chronic testing. The tests used marine organisms which were consistent with those used by WDOE for assessing other discharges in Puget Sound and have been shown to be sensitive to a range of environmental contaminants. WET tests were performed on overboard discharge samples that were diluted in the lab to evaluate common statistical endpoints (NOEC, LOEC, ECxx). Measurable effects on the test organism were only observed in the undiluted discharge water samples. Effects noted from chronic endpoints (e.g. growth, larval development) suggested that sand dollar larvae were generally the most sensitive organism tested, although slight effects on the growth (i.e. biomass) endpoint for the silverside test were also observed. Generally, the effects noted in the WET tests were ameliorated when the sample was diluted with clean seawater by 50 percent. Toxic units were calculated for each WET test and the highest toxic units for each round were used during the modelling that occurred for the in-port scenario.

9 MAMPEC modeling using mean discharge concentrations resulted in predicted environmental concentrations for the "In-Transit" scenario that were at background levels, which would suggest little to no ecological risk would be associated with these discharges while underway. An additional MAMPEC model of a worst-case metals scenario used the single maximum concentration for vanadium and nickel overboard discharge samples, and

[4] Toxic units represent the ratio between the concentration of a component in a mixture and its toxicological acute (e.g. LC50) or chronic (e.g. long-term NOEC) endpoint. The toxic unit of a mixture (TUm) is the sum of TUs of individual chemicals. Higher TUs indicate greater toxicity.

estimated that the concentration of these two metals in the receiving waters would be lower than the PNEC values, suggesting low risk to potentially exposed organisms.

10 MAMPEC results for the "in-port" scenarios indicate that for both the mean and worst-case (for nickel and vanadium) discharges, the receiving water concentrations remained close to background, below the most conservative PNEC concentrations, and are not expected to accumulate over time. Modeled estimates assumed one ship in port running one EGCS 24/7 for the entire year (actual occupancy is about 15% of the year, with half of that time on shore power).

11 CORMIX dilution modeling estimated reduction of the toxic units from the conservative TLM to less than 1.0 at a distance from discharge of between 4 and 50 meters, depending on tidal state. Using toxic units calculated from the WET tests this estimate would be less, between 0 and 6 meters from discharge.

Study conclusions

12 The findings of the Puget Sound study of exhaust gas cleaning system washwater discharges can be summarized as follows:

.1 all metals measured in the overboard discharge samples were lower than the United States EPA ambient water quality criteria and Washington State standards for those metals (no criteria or standard exists for vanadium), although nickel and vanadium were slightly above the European PNEC;

.2 WET tests showed limited chronic toxicity to tested organisms in undiluted overboard discharge waters;

.3 WET test results suggest that chemistry-based toxicity predictions (e.g. TLM) are inherently conservative and may overstate cumulative risks when compared to observed results from laboratory-based empirical toxicity tests, WET tests not only test the chemical constituents that are measured analytically, but also other unmeasured compounds present in the mixture, and any potential interactions that occur between compounds within the mixture;

.4 MAMPEC modeling for both the "in-transit" and the "in-port" scenarios showed no significant increase of predicted environmental concentrations above the background concentrations of receiving waters in either scenario, with a risk characterization ratio (RCR)[5] using estimated toxic units from either WET testing or TLM to be less than 1.0; and

.5 CORMIX modeling for the Port scenario estimated a reduction of toxic units calculated by WET test or TLM to be less than 1.0 at between 0 and 50 meters along the discharge centerline, depending on the toxic unit reference and the tidal state.

[5] RCR = Predicted Environmental Concentration (PEC)/Predicted No Effect Concentration (PNEC)) An RCR < 1 indicates that the identified risks are acceptable.

Risk assessment

13 For the "in-transit" scenario, the RCR calculated based on either the TLM, worst-case concentrations for nickel and vanadium, or WET testing estimated TU's comparable to the PEC's from the MAMPEC model and was less than 1.0 at the point of discharge suggesting little or no risk to the Puget Sound.

14 Using both MAMPEC and CORMIX models for the "in-port" scenario, the RCR using TU's from the TLM model was estimated to be less than 1.0 between 4 to 50 meters from the discharge point and along the discharge centre-line, depending on tidal state. The WET test calculated TUs would show an RCR of less than 1.0 at between 0 to 6 meters from the discharge point, depending on tidal state; again suggesting minimal ecological risk.

Action requested of the Committee

15 The Committee is invited to consider the information provided in this document and, in particular, its relevance to the ongoing deliberations under the PPR Sub-Committee on the evaluation and harmonization of rules and guidance on the discharge of discharge water from EGCS into the aquatic environment, including conditions and areas.