CRUISE SHIP DISCHARGES

MEMORANDUM OF UNDERSTANDING CRUISE OPERATIONS IN WASHINGTON STATE Exhaust Gas Cleaning Systems Washwater Discharges - Evaluation

Amy Jankowiak

Municipal Compliance and Vessel Sewage Prevention Specialist,
Water Quality Program

April 2, 2019

DEPARTMENT OF ECOLOGY
State of Washington

Exhaust Gas Cleaning Systems Overview

- What they are
  - Exhaust stream mixed with seawater or fresh water to remove sulfur
  - Solids separation
  - Some with additional filtration
- Why being installed
  - Global efforts to reduce air emissions from ocean-going vessels; sulfur content from 3.5% to 0.5% by 2020
  - Puget Sound is in N. America emission control area has required sulfur content of 0.1% since 2015
- Types of systems
  - Open-loop
  - Closed - hybrid
  - Closed

Exhaust Gas Cleaning Systems Washwater Evaluation

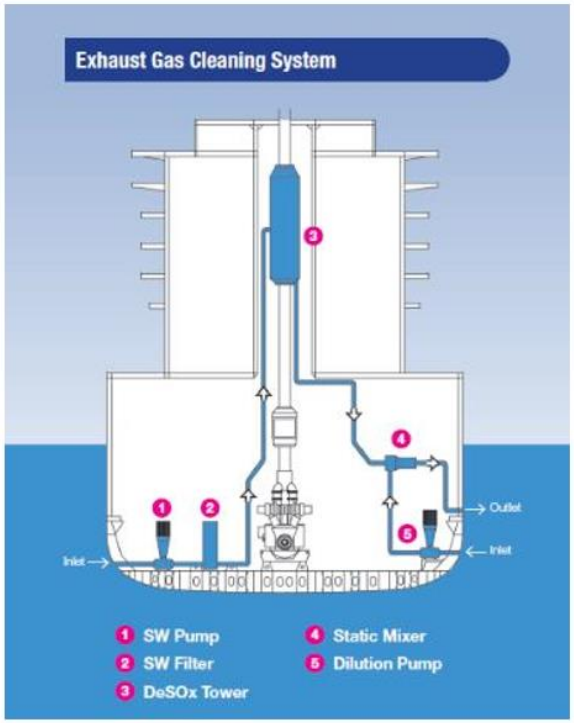
- SCOPE
  1. Compile & review existing available information:
     a) Operational characteristics
     b) Discharge information
     c) Water quality data
     d) Regulatory context – status, applicability, comparisons
  2. Briefing by CLIA-NWC – Carnival
  3. Summary of information at annual meeting with data gaps and recommendations

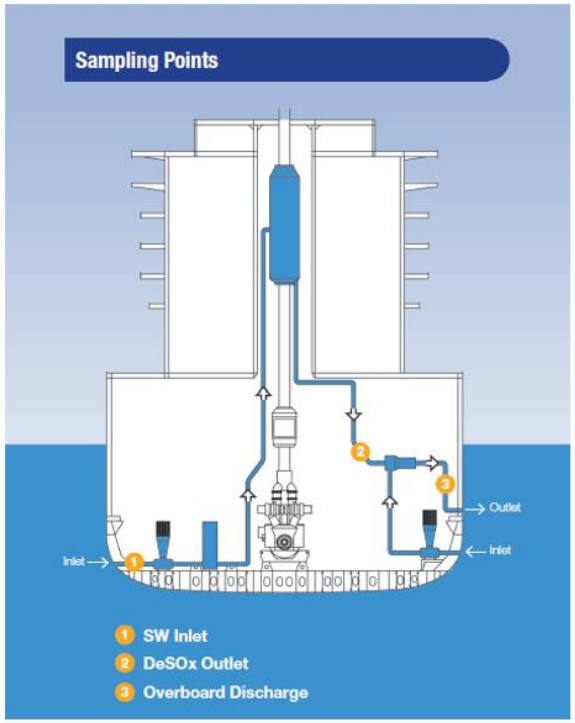
Exhaust Gas Cleaning Systems Operational Characteristics

- Open loop
  - Seawater drawn into EGCS; mixed with exhaust gases; buffering of seawater dissolves/removes SOx producing sulfurous acid/sulfuric acid/calcium sulfate; some have additional filtration; addition of seawater for pH buffering. Solids removed, stored, and sent for shoreside disposal.
- Closed loop/hybrid
  - Fresh water and often caustic soda mixed and introduced to exhaust gases to chemically remove SOx; circulated internally; treated to remove some contaminants; bleed-off water sometimes continuously discharged and sometimes held for later discharge; hybrid either open or closed.
- Time for changeover from fuel sources – changeover starts to be ready for compliance
- Different requirements in different locations

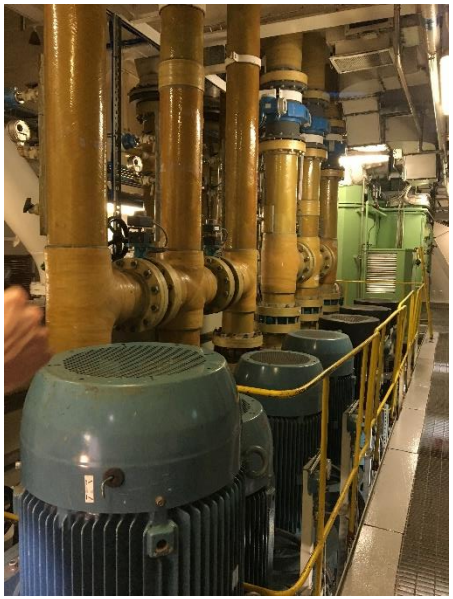
Example Open Loop System and Sampling locations

Carnival Open Loop EGCS (DeSOx)





NOTE: Sampling points are installed at the seawater inlet (1), the DeSOx outlet (2) and before the overboard discharge (3). Net post-EGCS values were calculated by comparing the DeSOx outlet values (2) with SW inlet values (1).



Water feed pumps and mixing/dilution pumps; ZAANDAM 7-30-18 Jankowiak

Intake filter; ZAANDAM 7-30-18 Jankowiak

Bag filters; GRAND PRINCESS 9-26-18 Jankowiak

Monitoring rack; ZAANDAM 7-30-18 Jankowiak

Soot sludge; NORWEGIAN BLISS 9-8-18 Jankowiak

Soot filter; ZAANDAM 7-30-18 Jankowiak

Washington State Specifics

2018 Cruise Ship Statistics

- 21 cruise ships to Seattle
- 216 calls
- Avg 10.5 hrs at berth ~ 18 hrs in WA waters
- Type by calls:
  - 53% open loop
  - 40% hybrid
  - 6% none – low sulfur fuel
  - 1% unknown
- Unknown length of time discharges in WA waters
- Discharge volume variable and includes seawater

Exhaust Gas Cleaning Systems Regulatory Context

- Comparisons
  - International Maritime Organization (IMO) Marine Environmental Protection Committee MEPC 259. (10)
  - EPA Vessel General Permit (VGP) 2.2.26
  - WA Surface Water Quality Standards Ch. 173-201A WAC

pH

Parameter	International - IMO MEPC	US EPA VGP	WA WQ Criteria
	Applicable Discharge Limits		Ambient WQ Criteria
pH	≥6.5 at OB discharge except during maneuvering/transit; max difference inlet/outlet 2 pH units [note IMO 6.5, VGO 6.0] OR The pH discharge limit, at the overboard monitoring position, is the value that will achieve as ≥6.5 at 4 m from the overboard discharge point with the ship stationary; can be calculated.	≥6.0 at OB discharge except maneuvering and transit max difference b/w inlet and outlet of 2.0 pH allowed.	pH must be within the range of 7.0-8.5 with a human-caused variation within the above range of less than 0.2 units.

- WA most stringent; EPA more stringent than IMO
- Includes only cruise vessel data

EPA Data Mean	Comparison
6.36 mean of avg 5.77 mean of min*	More acidic than WA criteria

PAH

Parameter	International - IMO MEPC	US EPA VGP	WA WQ Criteria
	Applicable Discharge Limits		Ambient WQ Criteria
Polycyclic Aromatic Hydrocarbons (PAH)	Flow rate (t/MWh) / Discharge Concentration limit (µg/L PAH_{phe} equivalents) 0-1 / 2250 2.5 / 900 5 / 450 11.25 / 200 22.5 / 100 45 / 50 90 / 25 For a 15-min period in any 12-hr period, PAH concerntration may exceed above by 100%.	Flow rate (t/MWh) / Discharge Concentration limit (µg/L PAH_{phe} equivalents) 0-1 / 2250 2.5 / 900 5 / 450 11.25 / 200 22.5 / 100 45 / 50 90 / 25 For a 15-min period in any 12-hr period, PAH concerntration may exceed above by 100%.	Components of PAH are included in human health criteria (6 of 11): benzo(a)anthracene 0.014/0.021/.00016 benzo(a)pyrene 0.0014/0.0021/0.000016 benzo(b)fluroanthene 0.014/0.021/0.00016 chrysene 1.4/2.1/0.016 dibenz(a,h)anthracene 0.0014/0.0021/0.000016 indeno(1,2,3-cd)pyrene 0.014/0.021/0.00016

- IMO and EPA match; WA listed differently; includes all vessel data, not just cruise

EPA Data Mean (ug/l)	Comparison
PAH = 25.2	PAH - Depends on flow rate compared to IMO and EPA limits
Benzo(a)anthracene = 0.454 Benzo(a)pyrene = 0.225 Benzo(b)fluroanthrene = 0.662 Chrysene = 0.699 Dibenzo(a,h,)anthracene = 0.173 Indeno(1,2,3-cd)pyrene = 0.176	EPA mean concentrations higher than WA or federal Human Health Criteria for certain PAH components (listed parameters are greater than Criteria; 11 PAH parameters have Human Health Criteria)

Turbidity and Aesthetics

Parameter	International - IMO MEPC	US EPA VGP	WA WQ Criteria
	Applicable Discharge Limits		Ambient WQ Criteria
Turbidity	Turbidity should not be greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, above the incoming seawater turbidity.	Turbidity should not be greater than 25 FNU (formazin nephlometric units) or 25 NTU (nephlometric turbidity units) or equivalent units, above the incoming seawater turbidity.	Turbidity must not exceed: 5 NTU over background when the background is 50 NTU or less; or a 10% increase in turbidity when the background turbidity is more than 50 NTU.
Aesthetic Value	None Established	None Established	Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

- Turbidity: IMO and EPA the same; WA depends on background turbidity, more stringent <50 NTU
- Aesthetics: no limits in IMO or EPA; WA criteria most stringent
- Surface effects occur under some conditions

Turbidity: EPA Data Mean	Comparison
8.2 FNU	Depends on background

Nitrates+Nitrites

Parameter	International - IMO MEPC	US EPA VGP	WA WQ Criteria
	Applicable Discharge Limits		Ambient WQ Criteria
Nitrates + Nitrites	Flow rate (t/MWh) / Discharge Concentration limit (mg/L nitrate + nitrite) 0-1 / 2700 2.5 / 1080 5 / 640 11.25 / 240 22.5 / 120 45 / 60 90 / 30	Flow rate (t/MWh) / Discharge Concentration limit (mg/L nitrate + nitrite) 0-1 / 2700 2.5 / 1080 5 / 640 11.25 / 240 22.5 / 120 45 / 60 90 / 30	No direct WQ criteria, however, affects DO which does have criteria (1-day minimum in mg/l, except by natural conditions, not decrease more than 0.2 mg/l…): Lowest 1-day minimum of 7.0 mg/L Dissolved Oxygen.

- IMO and EPA match; WA listed differently
- Includes all vessel data, not just cruise

Toxics

Parameter	International - IMO MEPC	US EPA VGP	WA WQ Criteria
	Applicable Discharge Limits		Ambient WQ Criteria
Toxics	None Established	None Established	Toxic, radioactive, or deleterious material concentrations must be below those which have the potential, either singularly or cumulatively, to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health.
Specific Toxics	None Established	None Established	all criteria in µg/l (acute / chronic) Arsenic 69 / 36 Cadmium 42 / 9.3 Chromium (VI) 1,100 / 50 Copper 4.8 / 3.1 Lead 210 / 8.1 Mercury 1.8 / 0.025 Nickel 74 / 8.2 Selenium 290 / 71 Silver 1.9 (acute only) Zinc 90 / 81

- no limits in IMO or EPA; WA criteria more stringent
- Cruise ship data only

Toxics cont.

Parameter	EPA Data Mean (ug/l)	WA WQ Criteria (marine aquatic life criteria: acute / chronic)	Comparison
Arsenic	26.64	69/36	Within WA Aquatic Life Criteria
Cadmium	10.25	42/9.3	Mean concentrations higher than WA Aquatic Life Chronic Criteria
Chromium	24.33	1,000/50	Within WA Aquatic Life Criteria
Copper	63.26	4.8/3.1	Mean concentrations higher than WA Aquatic Life Acute and Chronic Criteria
Lead	22.64	210/8.1	Mean concentrations higher than WA Aquatic Life Chronic Criteria
Nickel	80.09	74/8.2	Mean concentrations higher than WA Aquatic Life Acute and Chronic Criteria
Selenium	42.31	290/71	Within WA Aquatic Life Criteria
Zinc	67.89	90/81	Within WA Aquatic Life Criteria

- Some data is above detection levels that are significantly higher than the criteria.
- Total (not dissolved); includes cruise ship only data.
- Inlet/background data not evaluated.

Exhaust Gas Cleaning Systems Washwater Research

- Studies reviewed from:
  - Danish Ministry of the Environment 2012
  - CE Delft 2015
  - Germany – Federal maritime and Hydrographic Agency 2018 (preliminary findings)
  - Carnival Corporation DNV/GL 2019
  - EPA 2011
  - Japan – Ministry of Land Infrastructure, Transport and Tourism 2019
- Generally not a lot of research available
- Regulatory agencies and industry have evaluated
- Decisions by countries and ports have varied
- Industry and science ramifications from IMO policy
- Recent submittal to IMO for reconsideration

Exhaust Gas Cleaning Systems Carnival Briefing

- Briefing to Ecology/Port of Seattle in December 2018
- Based on report "Compilation and Assessment of Lab Samples from EGCS Washwater Discharge on Carnival Ships" 2019
- Sampling (EPA approved methods/accredited labs)
  - 281 samples; 53 ships; 54 chemical constituents per sample
  - Constituent content per liter of water avg flow rate 45t/MWhr; results – averages, post-EGCS minus inlet water values, outliers eliminated
  - Showed sample avg PAH and nitrate levels below IMO wash-water guidelines; German ordinance and EU's standards

Exhaust Gas Cleaning Systems Summary

- Existing information available on
  - Operations
  - Water quality data
  - Laws, regulations, permits
  - Available research
- Initial data review shows certain parameters at times elevated above WA WQ criteria
- Research shows variabilities in the contents of washwater and how ships' EGCS function

Exhaust Gas Cleaning Systems Data Gaps

- Surface effects characterization
- Discharge volume and frequency
- Bioaccumulation
- Loading of the discharges specific to Washington waters
- Effect of fuel choices on environmental media
- Other international regulations/limits
- Whole effluent toxicity testing
- Modeled effects of discharges to WA waters
- Relationship between system O&M and discharge quality

Exhaust Gas Cleaning Systems Washwater Preliminary Recommendations Port and Ecology Staff

- Prioritize data gaps
- Potential approach:
  - Identify a funding mechanism.
  - Gather additional information to identify EGCS discharges that may require controls in order to protect water quality.
  - Explore an amendment to the MOU that exceeds regulation.
  - As funded, develop scope and timeline.

Amy Jankowiak, Municipal Compliance & Vessel Sewage Prevention Specialist,
Dept. of Ecology Northwest Regional Office
(425) 649-7195
amy.jankowiak@ecy.wa.gov

Ecology Website: https://ecology.wa.gov/

New Cruise Ship Website:
https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Cruise-ship-memorandum-of-agreement-MOU