CROWLEY
People Who Know

Background

General Information

Ocean Ranger Name:	richard.ekstrom
Report Date:	Jul 5, 2018
Ship:	Holland Westerdam
Ship Code:	HWE

Section 1: Scrubber Installation and Operation

1. Is the vessel operating or installing an exhaust gas scrubber system in the 2017 Alaska Cruise Season? If you answered Yes, continue to the next page. If you answered No, answer the next 3 questions and submit the report.	Yes

Section 1: Scrubber Installation and Operation, ctd.

2. Physical location of the scrubber system, and if applicable, list the "removed" engine / sundries / stack equipment to accommodate the scrubber installation?	DeSox towers for units #1 and #2 are in the aft stack. DeSox towers for units #4 and #5 are in the forward stack. One incinerator was removed for pump installation. The silencers were removed from the uptakes of the diesels for installation of scrubbers.
3. What is the location and source that the scrubber system is installed to treat? Include design capacity etc. of the fuel oil combustion equipment (include maximum power rating).	Diesel Generator #1 Diesel Generator #2 Wartsila 16ZA40S. Wartsila 12ZA40S 11,520 KW. 514 rpm. 4 stroke 8,640 KW. 514 rpm. 4 stroke DG Serial no. 12342 DG Serial no. 12346 EGC Tower no. 13-036-APC-DG 1 EGC Tower no. 13-036-APC-DG 2 Diesel Generator # 4 Diesel Generator #5 Wartsila 16ZA40S Wartsila 12ZA40S 11,520 KW. 514 rpm. 4 stroke 8640 KW. 514 rpm. 4 stroke DG Serial no. 12343 DG Serial no. 12345 EGC Tower no. 13-036-APC-DG 4 EGC Tower no.16-286-APC-SC-500
4. Brand, make, model, or other identification information for the scrubber system. Who installed the system? Certification of the system IMO ANNEX VI certification? Classification?	Manufactured by: Ecospray Technologies S.r.l. Init model: ECO-DeSox IMO number: 9226891 Ecospray project no. 13-036-APC/16286-APC Lloyd's design appraisal document: 07 May 2018
5. Scrubber type, e.g. closed, reagent cycle, combination or hybrid, or open-loop effluent to seawater?	The scrubbers on the Westerdam are wet open loop.
6. System status, i.e.: operational, commissioning, under construction, etc.? Expected install date?	The scrubbers are up and running on DG's 1, 2, 4, and 5.
7. Process description and waste flow (gaseous emissions, waste effluent, ash or spent reagent, etc.)?	DG #2 and DG #4 have in port filters installed which are located downstream of the towers in the stack area. DeSox wash water flows through these Alpha filters, which are bag type 50 micron filters. A back wash system helps keep these filters clean. After passing through these filters the wash water is pumped to another set of filters located in the garbage room. These are bag

	type 80 micron filters. Pressure differential in these filters determines when they are required to be cleaned. Any carbon or soot from the filters is put in bags and offloaded as non hazardous waste. No chemicals or additives are used in scrubber operations. In addition, DG #2 has a gas trap installed in an attempt to capture soot particles. However, the effectiveness of the trap has been reported to be less than successful.
8. Additives used for the scrubber process? (De-sludge's etc.) If so full description.	There are no additives used in the exhaust gas cleaning system.
9. Describe the materials used in the piping systems.	The piping is GRE, glass reinforced type material.
10. System capacities and mode of operations, bottlenecks, etc.? E.g. pump(s) capacity and control (constant or variable speed), systems energy consumption, etc.	Exhaust gas cleaning systems are a work in progress. Some bottlenecks: The motors on the dilution pumps were originally 45 KW but were increased to 75 KW for more power and water flow. In port filters were added to DG #2 and DG #4 to help in filtering and cleaning wash water. As observed by many Ocean Rangers the in-port filters don't always clean the wash water as sheens have been evident. Different areas have different levels of pH. With low alkalinity (i.e. Skagway, according to scrubber engineer) it has been difficult for the EGCS to achieve their required pH numbers on the wash water discharge. With that problem in mind, the EPA has granted an exemption to sailing in waters with low pH. In those waters with low pH if the ship is underway then as long as the difference between the pH of the intake water and the pH of the wash water discharge is 2 or less then compliance parameters for pH have been met. The tower for DG #5 is a newer variety and has three row of spray valves to aid in scrubbing more exhaust gases. The older towers had two rows. A gas trap has been added to DG #2 to help in capturing more soot particles. Pump capacities are listed below, in the next question.
11. Discharge volume(s) for pumps in (m3/hr)? Note: if pump speed varies pending on operation include the capacities by each speed setting, including the max cap and low cap, etc. -If applicable, include the intake volume of the pump(s) system. See previous Note.	The wash water pumps are variable speed with a minimum setting of 350 m3/hr. and a maximum setting of 800m3/hr. The pumps are on automatic setting and will ramp up or down in order to maintain a setting of 4.3 for the SO2/CO2 ratio. The dilution pumps are variable sped from 350m3/hr. to 1300m3/hr. and will ramp up or down in order to maintain an overboard pH of 6 or higher.
12. Ash/ sludge removal or catchment in the system and how disposed of? Average waste production 24-hrs, etc.	80 micron bag type filters clean the wash water and are located in the garbage room. Pressure differential determines when it's necessary to clean the filters. The filters are being changed once a week and are offloaded as non hazardous waste.

13. Fuel use? Fuel specification limits for the scrubber system? How is fuel tracked or monitored to determine removal efficiency and compliance status?	The system operates on fuel with a sulfur content of less than 2%. Fuel bunkered has been on average 1.2% to 1.6% . Bunkering receipts verify the sulfur content and a sample is also sent to a lab for independent verification. Compliance status is tracked on a computer program called Neptune which is accessible by the home office in real time. Any alarms or failures on the system are investigated by the scrubber engineer. Company policy allows a six hour time frame in which any malfunctions must be repaired or the diesel online will have to do a fuel switchover to MGO.
14. General notes on scrubber operations & maintenance, instructions, logs, etc?	An alarm log is kept in the ECR. A compliance computer is accessed by the scrubber engineer in his office or in the ECR. Manuals and instructions are hard copy or computer recorded. Repairs and proper functioning of the system is performed by the dedicated scrubber engineer.
15. For seawater intake/effluent, please provide port locations (PS/STB Frame number, etc.)? Additional notes can include distance below waterline or vertical angle.	Sea water intake for DGs 1,2 and 4 is on the starboard side between frames 86 to 94. This is the incinerator room. Sea water intake for DG #5 is at frame 130 on the port side.

Section 2: Compliance and Auxiliary Monitoring - Water & Solid Waste

16. Pursuant requirements of EPA VGP 2.2.26, 40 CFR 110, and section 10 for Exhaust Gas Cleaning (EGC) Systems under IMO (resolution MEPC.184(59)), does the vessel monitor scrubber system parameters for the following items, (Notes: include sampling schedule or monitoring interval (e.g. twice per second, once per minute, etc.,) you may circle Yes (Y), No (N), or units measured where applicable,);	Rack 1 is at the sea suction and measures pH, PAH, turbidity and temperature. Measurements are continuous. Rack 2 is at the outlet of the DeSox towers and measures pH, PAH and turbidity. Measurements are continuous. Rack 3 is at the overboard discharge and measures pH on a continuous basis. An EMSYS computer is located in the upper stack. A gas sample is drawn from the stack, cooled down, and excited by a laser beam. The system will produce an SO2/CO2 ratio. Parameters require that ratio to be at 4.3 or below.
16.a pH	
16.a.1 Is intake monitored?	Yes
16.a.2 How?	There is a pH monitor on the sea water intake and a pH monitor on the discharge side after the static mixer. The measurement is continuous on a 0-14 scale.
16.a.3 Is effluent monitored?	Yes
16.a.4 How?	Rack 2 measures wash water discharged from the tower and records pH, pah and turbidity with a Hach Lange sensor.
16.b PAHs (Polycyclic Aromatic Hydrocarbons) µg/L PAHphe (phenanthrene equivalence)	
16.b.1 Is intake monitored?	Yes
16.b.2 How?	From a Hach Lange sensor on the sea water intake (Rack 1) and from a Hach Lange sensor on the wash water from the DeSox tower (Rack 2). The measurements are made by a UV fluorescent light and are continuous.
16.b.3 Is effluent monitored?	Yes
16.b.4 How?	PAH is measured by Rack 2 from the wash water outlet.
16.c Oily discharges or sheens	

16.c.1 Is effluent monitored?	No
16.c.2 How?	Oily discharges and sheens are not measured or recorded (except by the Ocean Ranger).
16.d Sludge or residues generated in treatment	
16.d.1 Is effluent monitored?	No
16.d.2 How?	Sludge, soot or other debris is filtered by bag filters located in the garbage room. These filters are cleaned when a set differential indicates dirty filters. Dirty filters are offloaded as non hazardous waste in Vancouver.
16.d.3 Where offloaded?	Vancouver
16.e Flow rate t/hr	
16.e.1 Is intake monitored?	Yes
16.e.2 How?	Wash water pumps are measured via HMI computer screen in m3/hr
16.e.3 Is effluent monitored?	Yes
16.e.4 How?	Dilution flow is measured by dilution pump pressure and volume.
16.f Scrubber system power consumption MWH.	
16.f.1 Present?	No
16.f.2 How?	Not measured
16.g Turbidity in any of the following units: FNU (Formazin Nephelometric Units), NTU (Nephelometric Turbidity Units), or equivalent units.	
16.g.1 Are other equivalent units used?	Yes
16.g.2 What kind?	Nephelometry Turbidity Units
16.g.3 How?	Turbidity sensor sends a beam of light through the wash water which is deflected by dense particles. The level of deflection is converted to a turbidity reading. Turbidity at sea suction and DeSox outlet is measured continuously on a range of 0.0001-1000FNU.
16.g.4 Is intake monitored?	Yes
16.g.5 How?	Water rack 1 at the sea suction is measured for pH, PAH, turbidity, and temperature.
16.g.6 Is effluent monitored?	Yes
16.g.7 How?	Rack 2 measures turbidity at the DeSox outlet.
16.h mg/L nitrate + nitrate	
16.h.1 Is effluent monitored?	No
16.h.2 How?	Not measured
16.i Temperature	
16.i.1 Is intake monitored?	Yes
16.i.2 How?	Temperature probes are are installed on the sea water lines and temperature thermocouples are installed on exhaust gas lines.
16.i.3 Where?	Temperature probes are are installed on the sea water lines and temperature thermocouples ate installed on exhaust gas lines.
16.i.4 Is effluent monitored?	Yes
16.i.5 How?	By the above mentioned temperature sensors.

16.i.6 Where?	At the discharge outlet for effluent and exhaust gas outlets for exhaust
17. How are monitoring systems secured, data collected, e.g. white-box, etc?	Data is collected and uploaded into the environmental compliance computer in the ECR. In addition, data is recorded into a system called Neptune which can be accessed in real time by the home office. The scrubber engineer can change parameters through the HMI screen in the ECR. That screen can be set to change the area from VGP waters (Alaska) to ECA waters. Outside VGP waters a pH of 4 is acceptable.
18. Do the monitoring systems have alarms or warnings in place for non-compliance?	Yes. Alarms indicate non compliance, in which case the scrubber engineer is notified to commence repairs.
19. Are sensors calibrated? Certified and to what standard (Note: critical for pH electrode and turbidity monitors) How often? Records or instructions? Generic notes for monitoring system "robustness"?	PH sensors are calibrated annually. The sensors are cleaned every 90 days. Recommendation is to replace the salt bridge and fill solution annually. Turbidity sensor maintenance is: Replace wiper profile after 1200 cycles. Replace desiccant every two years. Maintenance for the PAH sensor: Perform factory calibration with UV fluorescence calibration every two years. Check plugs and flash bulbs every two years. The CO2/SO2 ratio is measured by the EMSYS system. Calibration gas with SO2 and CO2 concentrations are used; these gases are within 80 to 100% of specific ranges.
20. Are their vessel procedures for system switch-over between operational modes, startup, shut-down, docking/maneuvering, etc. and how is this done?	At start up the EGCS will be put online prior to starting the engine. At shut down the engine will be secured and then the EGCS will be secured. To switch from HFO to MGO the procedure follows: 1. Reduce load to approximately 7MW. 2. Shut off steam supply to booster module. 3. Shut off steam supply to tracing lines. 4. Fuel temp at 85*C switch 3 way valve to MGO. 5. Fuel temp at 70*C open MGO return line cooler The ship has been operating an engine with an in port filter while at Alaskan docks. They have not switched to MGO while tied up during this two week observation period. They will switch to MGO while in Glacier Bay.
21. How and where does the vessel intend to satisfy compliance with receiving water monitoring requirements for EGCs under the EPA VGP 2.2.26.2.3 and if conducted, are reports, or documentation available for 2.2.26.2.4 (Annual EPA VGP DMR, due by February 28 of the following year)?	On an annual basis sample boxes will be sent to the ship. The EO will draw all required samples which will be put in a cooler. Location will dictate when samples are best drawn as some samples need to be sent to the lab in a given period of time. DG #5 is in the first year of operation which requires a water sampling be performed twice in the first year.

Section 3: Compliance and Auxiliary Monitoring - Air

22. Describe or provide a diagram of exhaust air flow and stack emissions. Mark and describe the sensors / measurement points installed to collect and monitor exhaust flow data. Diagram may be scanned as a photo.	See photo section
23. Are there after-burners in the exhaust stack for scrubber emissions? Where? If so, what is the fuel consumption and operational control of this system?	There are stack heaters in the exhaust stack. An earlier problem with the EGCS was carryover. This was caused by moisture entrained in the stack gas condensing on the relatively cooler surface of the circular stack. These drops of water would then be carried

	out of the stack and often drop down on decks in the form of soot. The solution was to use a coil of wire on the inside of the stack which is heated to 40 degrees celsius and which acts to prevent condensation and the resulting carryover.
24. Economizer / Heat Recovery, how is "boiler (air side) washing performed? Soot blowing operations? Details include the frequency used equipment etc.	Soot blowing is done every night. Wash water cleaning is done every 500 hours and the dirty wash water is collected in barrels and offloaded.
25. Pursuant requirements of MEPC 59/24/Add.1 ANNEX 9, how and where is the SO2 (ppm)/CO2 (%) ratio monitored? -Additionally, how is fuel use in the associated combustion equipment tracked?	There is an EMSYS system in the upper part of the stack which will,draw in a gas sample, cool said sample, and that sample will be analyzed for SO2/CO2 ratio. Information is fed into the HMI computer. Wash water pumps are controlled automatically and will ramp up or down to satisfy the ratio.
26. How are monitoring systems secured, data collected, e.g. white-box, etc?	The information in the EGCS computer can not be deleted. In addition, when the system is running real time information is fed to the home office allowing them to monitor the system.
27. Do the monitoring systems have alarms or warnings in place for non-compliance?	Yes. There is an alarm panel in the ECR which alerts the watch standing engineer whenever the EGCS is out of compliance. The dedicated scrubber engineer will then be notified. Company policy permits the ship to run six hours out of compliance while repairs are made before switching engines or switching to MGO. In addition, the compliance computer is synced with the company home office computer, allowing shore side to be aware of alarm conditions.
28. Are sensors calibrated? Certified and to what standard? How often? Records or instructions?	Yes. Information from the sensors is read from Rack 1, Rack 2 and Rack 3. Calibration is described in a previous question. Parameters are: Ph greater than 6. PAH less than 72 ppb. Turbidity less than 25.0 FNU. SO2/CO2 less than 4.3. PH differential between water in and water out is required to be less than 2 if sailing in waters with low pH levels.
29. Are there vessel procedures for system switch-over between operational modes, startup, shut-down, docking/maneuvering, etc. and how is this done?	At start up the EGCS will be put online prior to starting the engine. At shut down the engine will be secured and then the EGCS will be secured. To switch from HFO to MGO the procedure follows: 1. Reduce load to approximately 7MW. 2. Shut off steam supply to booster module. 3. Shut off steam supply to tracing lines. 4. Fuel temp at 85*C switch 3 way valve to MGO. 5. Fuel temp at 70*C open MGO return line cooler The ship has been operating an engine with an in port filter while at Alaskan docks. They have not switched to MGO while tied up during this two week observation period. They will switch to MGO while in Glacier Bay.

Section 4: General Observations

30. Is vessel crew cooperative on this project?	Yes. Mainly the scrubber engineer who is very dedicated to his job. Carnival Corp. keeps track of the hours scrubber are in use for every ship in their fleet and the Westerdam is always ranked in the top three.

31. Do you feel the vessel has a "good grip" on compliance requirements; how difficult is this survey to complete?	There has been enough time to fully understand compliance requirements. There has not been enough time to determine the toxicity, or not, of the scrubber discharge.
32. Are there other remarks/ comments the OR wants to share?	. At some point there should be a final determination as to what is an acceptable scrubber discharge regarding sheens or floating debris.

Photos and Comments

Photo 1

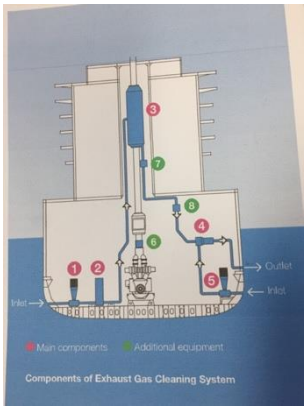
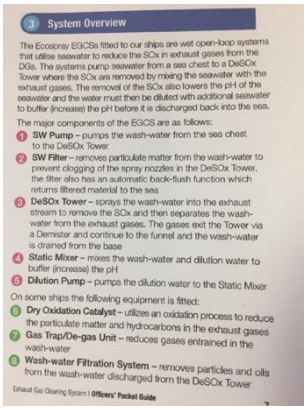


Photo 1 Caption

Diagram of DeSox tower. (Note: #6 in the digram is not present on the diesels. All the other data corresponds). (Note: There is a gas trap unit on #2 DG only).

Photo 2



3 System Overview

The Ecospray EGCSs fitted to our ships are wet open-loop systems that utilise seawater to reduce the SOx in exhaust gases from the DGs. The systems pump seawater from a sea chest to a DeSOx Tower where the SOx are removed by mixing the seawater with the exhaust gases. The removal of the SOx also lowers the pH of the seawater and the water must then be diluted with additional seawater to buffer (increase) the pH before it is discharged back into the sea.

The major components of the EGCS are as follows:

1. **SW Pump** – pumps the wash-water from the sea chest to the DeSOx Tower
2. **SW Filter** – removes particulate matter from the wash-water to prevent clogging of the spray nozzles in the DeSOx Tower, the filter also has an automatic back-flush function which returns filtered material to the sea
3. **DeSOx Tower** – sprays the wash-water into the exhaust stream to remove the SOx and then separates the wash-water from the exhaust gases. The gases exit the Tower via a Demister and continue to the funnel and the wash-water is drained from the base
4. **Static Mixer** – mixes the wash-water and dilution water to buffer (increase) the pH
5. **Dilution Pump** – pumps the dilution water to the Static Mixer

On some ships the following equipment is fitted:

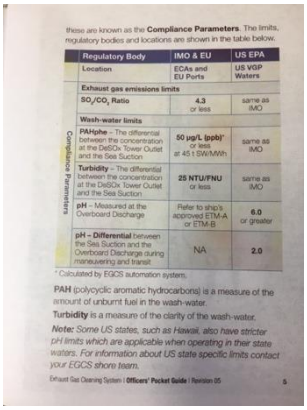
6. **Dry Oxidation Catalyst** – utilizes an oxidation process to reduce the particulate matter and hydrocarbons in the exhaust gases
7. **Gas Trap/De-gas Unit** – reduces gases entrained in the wash-water
8. **Wash-water Filtration System** – removes particles and oils from the wash-water discharged from the DeSOx Tower

Exhaust Gas Cleaning System | **Officers' Pocket Guide**

Photo 2 Caption

Description of parts for above diagram.

Photo 3



those are known as the **Compliance Parameters**. The limits, regulatory bodies and locations are shown in the table below.

	Regulatory Body	IMO & EU	US EPA
	Location	ECAs and EU Ports	US VGP Waters
Compliance Parameters	**Exhaust gas emissions limits**		
	SO_2/CO_2 Ratio	4.3 or less	same as IMO
	Wash-water limits		
	PAHphe – The differential between the concentration at the DeSOx Tower Outlet and the Sea Suction	50 µg/L (ppb)* or less at 45.1 BW/MWh	same as IMO
	Turbidity – The differential between the concentration at the DeSOx Tower Outlet and the Sea Suction	25 NTU/FNU or less	same as IMO
	pH – Measured at the Overboard Discharge	Refer to ship's approved ETM-A or ETM-B	6.0 or greater
	pH – Differential between the Sea Suction and the Overboard Discharge during maneuvering and transit	NA	2.0

* Calculated by EGCS automation system.

PAH (polycyclic aromatic hydrocarbons) is a measure of the amount of unburnt fuel in the wash-water.

Turbidity is a measure of the clarity of the wash-water.

Note: *Some US states, such as Hawaii, also have stricter pH limits which are applicable when operating in their state waters. For information about US state specific limits contact your EGCS shore team.*

Exhaust Gas Cleaning System | **Officers' Pocket Guide** | Revision 05 5

Photo 3 Caption

Parameters used in ECA waters and in VGP waters is explained.

Photo 4

Photo 4 Caption

DG #5 wash water pump.

Photo 5

Photo 5 Caption

Sox filters for the EGCS are located in the garbage room. Filters were an add on to aid in cleaning wash water. Duplex filters are set up to switch automatically when a set differential pressure is met.

Complete

Is this report complete? Yes

If this report is complete, tap on Send now. Do not make a selection in the next field. The report will be submitted for final review.