United States Environmental Protection Agency
Office of Wastewater Management
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Graywater Discharges from Vessels

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SECTION 1
INTRODUCTION

The 2008 Vessel General Permit (VGP) regulates discharges incidental to the normal operation of vessels operating as a means of transportation. The VGP, like other general permits, is issued by the permitting authority (in this case, EPA) and covers multiple facilities within a specific category for a specific period of time (not to exceed 5 years). The 2008 VGP includes the following limits or requirements: general effluent limits applicable to all discharges; effluent limits applicable to 26 specific discharge streams; narrative water-quality based effluent limits; inspection, monitoring, recordkeeping, and reporting requirements; and additional requirements applicable to certain vessel types (USEPA, 2008a).

Because EPA plans to reissue the VGP, the Agency continues to gather information on vessel wastewater sources while examining technologies that can be used to remove pollutants before discharge into waters of the United States.[1] This document contains updated information on both vessel graywater discharge characteristics and recent developments in graywater treatment technologies.

1.1 WHAT IS GRAYWATER?

For purposes of the 2008 VGP, "graywater" means galley, bath, and shower water, as well as wastewater from lavatory sinks, laundry, and water fountains (USEPA, 2008a). Other regulations have expanded the definition of graywater to specifically include discharges from dishwashers. Table 1 shows various other definitions for graywater based on different regulations (USEPA, 2008b). According to information gathered by EPA during ship visits and via responses to EPA's survey of cruise ships operating in Alaska in 2004, the following waste streams were routed to the graywater system:[2]

- Wastewater from bar and pantry sinks;
- Wastewater from salon and day spa sinks and floor drains;
- Wastewater from interior deck drains, shop sinks, and deck drains in non-engine rooms;
- Refrigerator and air conditioner condensate;
- Wastewater from laundry floor drains in passenger and crew laundries;
- Dry cleaning condensate;
- Wastewater from garbage room floor drains and from sinks in restaurants and cafes;
- Wastewater from whirlpools; and
- Wastewater from medical facility sinks and medical floor drains.

These waste streams are not specifically listed in the 2008 VGP graywater definition, or within other regulatory definitions of graywater listed in Table 1, although some have similar characteristics. For example, wastewater from bar and pantry sinks would be expected to have characteristics similar to dishwasher wastewater.

[1] "Waters of the United States" as defined in 40 CFR 122.2.
[2] Note that the 2008 VGP prohibits some of the sources below from being discharged into waters subject to that permit.

Table 1. Graywater Definitions

Source	Graywater Definition
Clean Water Act, 33 U.S.C. § 312(a)(11)	Galley, bath, and shower water
International Maritime Organization Guidelines for Implementation of Annex V of MARPOL	Drainage from dishwasher, shower, laundry, bath and washbasin drains and does not include drainage from toilets, urinals, hospitals, and animal spaces, as defined in regulation 1(3) of Annex IV, as well as drainage from cargo spaces
Title XIV – Certain Alaskan Cruise Ship Operations, 33 U.S.C. § 1901 Note (Sec. 1414(4))	Only galley, dishwasher, bath, and laundry wastewater
Coast Guard regulations implementing MARPOL and the Act to Prevent Pollution from Ships, 33 CFR 151.05	Drainage from dishwasher, shower, laundry, bath, and washbasin drains and does not include drainage from toilets, urinals, hospitals, and cargo spaces

Graywater discharges can contain bacteria, pathogens, oil and grease, detergent and soap residue, metals (e.g., cadmium, chromium, lead, copper, zinc, silver, nickel, and mercury), solids, and nutrients (USEPA, 2008b; USEPA 2010). Wastewater from medical facility sinks and medical floor drains may contain constituents ranging from bacteria, nutrients, and oxygen-depleting substances (e.g., BOD_5), depending on the types of illness or treatment procedures being performed.

1.2 Regulatory Framework for Graywater Discharges

Graywater discharges from vessels operating in U.S. waters have historically been excluded as discharges incidental to the normal operation of a vessel from Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) permitting requirements through regulations at 40 CFR 122.3(a). However, in December 2003, the long-standing exclusion of discharges incidental to the normal operation of vessels from the NPDES program became the subject of a lawsuit in the U.S. District Court for the Northern District of California. On March 30, 2005, the same court determined that the exclusion exceeded the Agency’s authority under the CWA, and issued a court order vacating that exclusion. As a result, discharges incidental to the normal operation of a vessel, including graywater, became subject to CWA section 301’s prohibition against discharging without a NPDES permit, unless covered under an NPDES permit. On December 19, 2008, EPA issued the VGP to provide NPDES permit coverage for vessel discharges incidental to normal operation from commercial vessels greater than 79 feet into waters of the United States. Waters of the United States, as defined in 40 CFR 122.2, includes the 3-mile territorial sea as defined in Section 502(8) of the CWA, and inland navigable waters, including navigable waters of the Great Lakes subject to the jurisdiction of the United States (USEPA, 2008a). The 2008 VGP did not include discharges incidental to normal operation of vessels less than 79 ft and commercial fishing vessels[3], which are exempt from NPDES permitting until December 2013,[4] pursuant to a moratorium. Approximately 120,000 to 140,000 vessels fall under the moratorium, including commercial fishing vessels and

[3] Except for ballast water discharges, for which these vessels still required NPDES permit coverage

[4] Public Law (P.L.) 110-299, amended by P.L. 111-215.

those commercial vessels 79 feet or less in length. Discharges from recreational and armed forces vessels are also permanently excluded.[5]

The 2008 VGP includes several best management practices (BMPs) that EPA determined are practicable and achievable for the control of graywater impacts (USEPA 2008a). First, all vessels must minimize the production and discharge of graywater while in port. For vessels that cannot store graywater, the owner or operator should minimize graywater generation while in port. Second, vessels greater than 400 gross tons that regularly travel more than 1 nautical mile (nm) from shore and have the capacity to store graywater must discharge graywater greater than 1 nm from shore while the vessel is underway, unless the vessel meets the 2008 VGP graywater treatment standards.[6] Vessels that do not travel more than 1 nm from shore must minimize the discharge of graywater and, provided the vessel has available graywater storage capacity, must dispose of graywater on shore if appropriate facilities are available,[7] unless the vessel can meet the 2008 VGP graywater treatment standards. Third, vessel operators must minimize the introduction of kitchen oils to the graywater system. When cleaning dishes, vessel owners/operators must remove as much food and oil residue as practicable before rinsing dishes. Vessel owners/operators should not add oils used in cooking to the graywater system or discharge oils from the galley and scullery in quantities that may be harmful as defined in 40 CFR 110.[8] In addition, soaps and detergents used in any capacity that will be discharged as part of graywater must be nontoxic and phosphate-free, and should be biodegradable where possible. Additional management practices are also applicable if the vessel is within nutrient-impaired or protected waters of the United States.

Medium cruise ships (authorized to carry between 100 and 499 people for hire) and large cruise ships (authorized to carry 500 or more people for hire) with overnight accommodations have additional requirements for graywater discharges under the 2008 VGP. When pierside, medium and large cruise ships must discharge graywater to appropriate shore-side receiving facilities or treat graywater to meet discharge standards. When pierside, medium and large cruise ships traveling within 1 nm of shore must either store graywater in on-board holding tanks or treat graywater to meet the discharge standards. Untreated graywater can be discharged by medium and large cruise ships between 1 and 3 nm from shore if the vessel is traveling at 6 knots or greater (USEPA, 2008a).

Large ferries that are authorized by the Coast Guard to carry 250 or more people are also subject to additional graywater discharge requirements in the 2008 VGP; however, there are no numeric treatment standards. While pierside, large ferries must discharge graywater to shore-side reception facilities, if reasonably available. If shore-side reception facilities are not reasonably

[5] 2008.33 U.S.C.§§ 1342(r) and 1362(6)(A).

[6] Discharge standards for graywater are 20 CFU/100 mls (30-day geometric mean) for fecal coliform bacteria, 10 ug/L for total residual chlorine, and the secondary treatment standards for BOD_5, suspended solids, and pH as defined in 40 CFR 133.102.

[7] Appropriate reception facilities are those authorized for use by the port authority or municipality, and that treat the discharge in accordance with the reception facility's NPDES permit. USEPA, Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP).

[8] 40 CFR 110.3 defines oils that may be harmful as those which violate applicable water quality standards, or cause a film, or sheen, or discoloration of the surface of the water or adjoining shorelines, or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.

available, the large ferry must hold the graywater if the vessel has the holding capacity and discharge the effluent while underway outside 3 nm. If the large ferry operates within 3 nm of shore, the ferry must discharge graywater while sailing at a speed of at least 6 knots, if feasible.

Both medium and large cruise ships and large ferries are also required to maintain records estimating all discharges of untreated graywater, including date, location and volume discharged, and speed of the vessel at the time of discharge in their recordkeeping documentation. These records can be maintained as part of the vessels sewage and graywater discharge record book required under 33 CFR 159.315.

EPA estimates that approximately 70,000 vessels are subject to the VGP (USEPA, 2011); however, not all of these vessels generate graywater. The vast majority (78 percent) of these vessels that are subject to the VGP operate primarily in the Mississippi River System and the Gulf Intracoastal Waterway. Twenty-one percent operate along the Atlantic, Pacific, and Gulf Coasts, and just over 1 percent mainly ply the waters of the Great Lakes.

According to the U.S. Coast Guard's Marine Information for Safety and Law Enforcement (MISLE) database, there are approximately 70,000 additional U.S.-flagged commercial fishing vessels that may generate graywater (USEPA, 2010). However, these vessels currently fall under the moratorium that exempts all commercial fishing vessels from the 2008 VGP's requirements for discharges incidental to the normal operation of a vessel, including graywater.

After excluding barges (which generally do not generate graywater), EPA estimates there are between 43,000 and 50,000 vessels that may be subject to graywater discharge limitations under the next VGP. EPA reports there are between 43,000 and 45,000 vessels[9] associated with the current 2008 VGP whose Notice of Intent (NOI) status is either active or certified (i.e., in the waiting period prior to becoming active) (Albert, 2010).

Pursuant to section 312 of the CWA, certain vessels operating in the Great Lakes are required to treat graywater discharges differently than other vessels operating on other waters of the United States. With respect to "commercial vessels" (as defined at 33 U.S.C. § 1322(a)(1)) operating on the Great Lakes, graywater is included in the definition of sewage (33 U.S.C. § 1322(a)(6)), and thus subject to CWA § 312, not NPDES. On the Great Lakes, discharges of untreated graywater from commercial vessels are prohibited unless treated by a United States Coast Guard (USCG)-certified marine sanitation device (MSD).[10] Commercial vessels operating on the Great Lakes can instead place both graywater and sewage into holding tanks and discharge the wastewater to shore-side facilities if the vessel is not equipped with an MSD.

Certain vessels operating in Alaska have federal requirements for graywater discharges, beyond those provided in the 2008 VGP. On December 12, 2000, Congress enacted an omnibus appropriation that included new statutory requirements for certain cruise ship discharges

[9] Owner/operators only had to submit an NOI for a vessel if that vessel was greater than 300 gross tons or had the ability to carry 8 cubic meters of ballast water. Hence, there are some vessels larger than 79 feet, but smaller than 300 gross tons, which are covered by the VGP, but did not have to submit an NOI.

[10] For purposes of the CWA, a marine sanitation device is "any equipment for installation on board a vessel which is designed to receive, retain, treat, or discharge sewage, and any process to treat such sewage" (33 CFR 159.3).

occurring in Alaska (Departments of Labor, Health and Human Services, and Education, and Related Agencies Appropriations Act, 2001, Pub. L. No. 106-554, 114 Stat. 2763 enacting into law Title XIV of Division B of H.R. 5666, 114 Stat. 2763A-315, and codified at 33 U.S.C. § 1901 Note) (USEPA, 2008b). Title XIV sets discharge standards for sewage and graywater from certain cruise ships (those authorized to carry 500 or more passengers for hire) while operating in the Alexander Archipelago, the navigable waters of the United States in the state of Alaska, and within the Kachemak Bay National Estuarine Research Reserve.[11]

Based on the various regulations and permit requirements described above, only medium and large cruise ships, large ferries, and commercial vessels operating on the Great Lakes have specific discharge standards and/or treatment requirements mandating the use of a treatment technology for graywater under certain discharge conditions (e.g., large and medium cruise ships discharging graywater while at the pier, large cruise ships discharging graywater in Alaskan waters, commercial vessels discharging graywater in the Great Lakes, etc.). Requirements to hold graywater for discharge are also limited to a few specific conditions (e.g., for certain ocean going vessels) by the 2008 VGP. The remainder of this document describes the feasibility of expanding these requirements to apply to a greater number of vessels in U.S. waters or to broaden the discharge conditions under which they apply.

[11] Title XIV: Certain Vessels Operating in Alaska, 33 CFR 159, Part E.

SECTION 2
GRAYWATER CHARACTERISTICS

Graywater consists of discharges from galley, bath, and shower water, as well as wastewater from lavatory sinks, laundry, and water fountains (USEPA, 2008a). The volume of graywater generated depends largely on the type of vessel and the number of passengers onboard. For example, cruise ships generate more graywater than cargo ships since they have many more passengers and crew than other ships. Cruise ships also generate higher graywater volumes per capita because passengers on these vessels use galleys and accommodations (sinks and showers) to a greater extent than crew on cargo ships.[12]

Estimated graywater generation rates reported in response to EPA’s 2004 cruise ship survey ranged from 36 to 119 gallons/day/person, with an average of 67 gallons/day/person (USEPA, 2008b) for large cruise ships. During EPA’s 2004 Alaskan cruise ship sampling program, graywater generation was measured on one ship at 45 gallons/day/person (USEPA, 2006a). The 2004 cruise ship survey data indicate there is no relationship between per capita graywater generation rates and number of persons onboard the cruise ship. Estimated graywater generation rates reported in response to EPA’s 2004 cruise ship survey indicate that approximately 52 percent of graywater was from accommodations, 17 percent from laundries, and 31 percent from galleys. Total BOD_5 contributions associated with all graywater sources shows that 52 percent is from galleys, 38 percent from food pulper/food waste, 8 percent from accommodations, and 2 percent from laundry (EcoMarine, 2010).

To validate the information gathered from EPA’s 2004 cruise ship survey, EPA reviewed literature information on graywater generation from other cruise vessels. According to a report from the Baltic Marine Environment Protection Commission, cruise ship graywater generation is approximately 120 liters per person/day (32 gallons/day/person) (Hanninen, 2009). The Ocean Conservancy has estimated cruise ship grey water generation ranging from 114 to 322 liters per day (30 to 85 gallons/day/person) (Hanninen, 2009).

To determine the total annual volume of graywater generated by various classes of vessels, EPA used information collected from telephone calls with vessel operators together with typical passenger/crew numbers and graywater generation rates. Table 2 shows the total estimated graywater generation by various common vessel classes in U.S. waters.

[12] Passengers and crew on cruise ships are expected to generate more graywater per capita than the crew of a cargo ships since persons on cruise ships are engaged in leisure activities and more likely to use larger quantities of water for bathing, food preparation, etc.

Table 2. Estimated Annual Graywater Generation by Commercial Vessels Greater Than 79 Feet in Length in U.S. Waters

Vessel Class	Number of Vessels	Average Number of Passengers and Crew	Number of Days Vessel is Generating Graywater in U.S. Waters (days/yr)[a]	Graywater Generation Rate (gal/day/person)	Total Annual Graywater Generation In U.S. Waters (gallons/yr)
Large Cruise Ships	47[b]	3,506[c]	85[d]	45[e]	630,291,000
Medium and Small Cruise Ships	36[f]	187[g]	274[h]	45[e]	83,006,000
Passenger Ferries with Overnight Accommodations	6[i]	610[i]	274[h]	45[e]	45,128,000
Passenger Vessels Without Overnight Accommodations	106[j]	282[k]	274[h]	45[e]	368,568,000
Dry Cargo/Tanker Ships	970[l]	25[m]	60[n]	14[o] to 45[e]	20,370,000 to 65,475,000
Great Lakes Freighters	52[p]	24[p]	136[h]	45[e]	7,638,000
Off-Shore Utility Vessels	1,964[q]	4[r]	31[h]	45[e]	10,959,000
Public Vessels, Unclassified	559[s]	4[r]	88[h]	45[e]	8,855,000
Tug Boats/Push Boats	5,424[t]	6[u]	350[v]	12[w] to 45[e]	136,685,000 to 512,568,000
Fishing Vessels[z]	69,944[x]	7[y]	94[h]	45[e]	2,071,000,000

a. Within 3 nm of shore or anywhere in the Great Lakes.
b. (CLIA, 2010)
c. Average passenger and crew numbers calculated from Friends of the Earth (FOE) Report Card for Cruise Ships entering U.S. Waters (FOE, 2010).
d. Based on 31 cruise ships in Alaska from May-September in U.S. waters 60% of the time and 17 additional cruise ships outside Alaska within U.S. waters 2 days per week and 52 weeks per year.
e. Sampling Episode Report for Holland America Veendam (Sampling Episode 6503). Washington, DC (USEPA. 2006a).
f. Total number of small and medium cruise ships from EPA 2008 VGP Notice of Intent Application database.
g. Average crew and passengers calculated from 23 medium and small cruise ships.
h. (USEPA, 2006b)
i. Passenger ferries having overnight accommodations. Includes five Alaska Marine Highway ferries and one Great Lakes ferry having overnight accommodations.
j. Calculated based on a total of 7,833 inspected passengers vessels, of which 9 percent are greater than 79 feet (USEPA, 2010b). Based on personal contact with the Passenger Vessel Association, approximately 15% of passenger vessels greater than 79 feet in length (106 vessels) discharge and the remainder use holding tanks and discharge to shore-side facilities.
k. Average number of passengers and crew calculated based on random sampling of data from tour boats, dinner cruise vessels, wedding party boats, whale watching tours, and shuttle service vessels.
l. (US Army Corp of Engineers, 2009)
m. (Chamber of Shipping of America, 2010)
n. Estimated time container vessels are in U.S. water based on USEPA Region 9 analysis of USCG Marine Information for Safety and Law Enforcement (MISLE) data that indicates 2.3 days per port call. EPA assumed vessel is in port 2.3 days every 2 weeks, which equals 60 days/yr.
o. Calculated based on vessels using only galley operations while in port per personal communication with Horizon Lines (See Attachment B)
p. Total number of members is 55; however, two have holding tanks and discharge shore-side and a third vessel is the car ferry Badger that discharges shore-side (Lake Carriers Association, 2010).

q. Off-shore utility vessels include school ships, research vessels, supply vessels, industrial vessels, and mobile off-shore drilling units. Of the 5,610 utility vessels not classified as tugs and tows, 35% are greater than 79 feet in length (USEPA, 2010b)

r. Assumes off-shore utility vessels and public vessels have approximately four crew based on information in Great Lakes Fisheries Commission (Schneider, 2001).

s. Of the 622 public vessels, unclassified, 90% are estimated to be greater than 79 feet in length (USEPA, 2010b).

t. (US Army Corp of Engineers, 2009).

u. Based on personal contact with AEP River Operations (see Attachment B).

v. Assumes vessel is out of service for 15 days per calendar year for maintenance per personal contact with AEP River Operations (See Attachment B)

w. Based on personal contact with AEP River Operations, who indicated the majority of tug boats are "day-boats" and therefore crew are not living onboard (See Attachment B).

x. Total number of commercial fishing vessels (USEPA, 2010b).

y. Commercial fishing vessels typically include a captain, first mate, engineer, boatswain, and three deck hands according to the Bureau of Labor Statistics, Agriculture, Forestry and Fishing, 2010-2011 Edition.

z. Includes commercial fishing vessels of any length.

As expected, the class of vessels currently covered by the 2008 VGP that generates the largest volume of graywater is large cruise ships. Large cruise ships generate the largest volume of graywater due primarily to the large number of passengers and crew on these types of vessels. Medium and small cruise ships also generate relatively large volumes of graywater, also due to their relatively large number of passengers and crew. Surprising, however, is the relatively large volume of graywater generated by tug and push boats as compared to other types of vessels. Although the number of crew on tug and push boats is small in comparison to other vessels, there are a relatively large number of these vessels operating in U.S. waters (5,424), operating for a relatively large number of days, resulting in the generation of large volumes of graywater. Commercial fishing vessels, though currently excluded from NPDES permitting, may generate the highest total volume of graywater because of the large number of vessels in this class.

In 2000, the Alaska Cruise Ship Initiative (ACSI) led a voluntary sampling effort to characterize graywater (discharged without treatment) and treated sewage discharges from cruise ships. Twice during the 2000 cruise season, samples were collected from each sewage and graywater discharge port from each of the 21 large cruise ships operating in Alaska. Sampling was scheduled randomly at various ports of call and on all major cruise routes in Alaska. Analytes included total suspended solids (TSS), BOD5, chemical oxygen demand (COD), pH, fecal coliform, total residual chlorine, free residual chlorine, and ammonia for all samples, and priority pollutants (metals, hydrocarbons, organochlorines) for one sample per ship. Voluntary sampling continued at the start of the 2001 cruise ship season through July 1, 2001, when Alaska state graywater and sewage discharge regulations (AS 46-03.460 - 46.03.490) came into effect. Table 3 shows the number of graywater and treated sewage discharge samples collected from cruise ships that fall into the different concentration ranges (treated sewage sample characteristics are shown to provide context for the pollutant strength of graywater). The results of this sampling effort demonstrate that the strength of the graywater, as indicated by TSS, BOD_5, and COD, is variable, and that graywater can have high levels of fecal coliform bacteria (ADEC, 2001).

Table 3. Percentage of Large Cruise Ship Untreated Graywater and Treated Sewage Samples by Concentration Range

Analyte and Wastewater Type	Concentration Ranges				
Fecal Coliform (MPN/100 mL)	**0 to 200**	**200 – 1,000**	**1,000 – 1 million**	**1 million – 10 million**	**>10 million**
Percentage of Graywater Samples	22%	3%	42%	19%	14%
Percentage of Treated Sewage Samples	40%	9%	23%	22%	6%
TSS (mg/L)	**0 – 150**	**150 – 1,000**	**>1,000**		
Percentage of Graywater Samples	60%	35%	5%		
Percentage of Treated Sewage Samples	22%	61%	17%		
BOD_5 (mg/L)	**0 – 100**	**100 – 1,000**	**>1,000**		
Percentage of Graywater Samples	25%	55%	20%		
Percentage of Treated Sewage Samples	51%	46%	3%		
COD (mg/L)	**0 – 100**	**100 – 1,000**	**1,000 – 10,000**	**>10,000**	
Percentage of Graywater Samples	2%	68%	26%	4%	
Percentage of Treated Sewage Samples	0%	25%	62%	13%	

Source: (ADEC, 2001)

In 2004, EPA sampled wastewater from four large cruise ships that operated in Alaska to characterize graywater and sewage generated onboard and to evaluate the performance of the Zenon, Hamworthy, Scanship, and ROCHEM advanced wastewater treatment systems (AWTS). EPA analyzed individual untreated graywater sources (accommodations, laundry, galley, and food pulper wastewater) on each ship for over 400 analytes, including pathogen indicators, suspended and dissolved solids, BOD_5, oil and grease, dissolved and total metals, organics, and nutrients. In addition, laundry wastewater samples were analyzed for dioxins and furans, and galley wastewater samples were analyzed for organo-halide and organo-phosphorus pesticides.

Table 4 summarizes the average conventional and nonconventional pollutant concentrations measured in combined untreated graywater. The data in Table 4 indicate that untreated graywater characteristics are similar to, and in some cases have a higher concentration of constituents than, domestic sewage entering land-based wastewater treatment plants. For example, the BOD_5 of graywater measured by EPA in 2004 from large cruise ships (1,140 mg/L) is nearly four times higher than domestic sewage. The TSS concentration of graywater from cruise ships is nearly double the concentration expected from domestic sewage. The conclusion that that can be drawn from the pollutant concentration data in Table 4 is that graywater from commercial vessels has the potential to be as environmentally damaging to surface waters as untreated domestic sewage discharged in similar quantities.

Table 4. Analyte Concentrations Measured in Untreated Graywater from Large Cruise Ships in Alaska and Armed Forces Vessels

Analyte	Units	Average Untreated Graywater Concentrations			
		Large Cruise Ships (EPA 2004 Data)[a]	Large Cruise Ships (ASCI/ADEC Data)[b]	Armed Forces Vessels[c]	Domestic Sewage[d]
Alkalinity	mg/L	53.8	57.8	NR	NR
Ammonia Nitrogen	mg/L as N	2.13	2.21	102	12 - 50
BOD_5	mg/L	1,140	354	540	110 - 400
COD	mg/L	1,890	1,000	1,440	200 - 780
Chloride	mg/L	125	NC	NR	NR
Conductivity	uS/cm	427	2,250	NR	NR
Fecal Coliform		36,000,000 CFU/100 mL	2,950,000 MPN/100 mL	142,000 CFU/100 mL	10,000-100,000 CFU/100 mL[e]
Hexane Extractable Material	mg/L	149	78[f]	164	50 - 150
Nitrate/Nitrite	mg/L	0.087	0.009	3.2	NR
pH	s.u.	6-9	6-9	NR	NR
Settable Residue	mg/L	25.6	1.1	NR	NR
Silica Gel Treated Hexane Extractable Material	mg/L	36.6	NC	NR	NR
Sulfate	mg/L	49.9	NC	NR	NR
Temperature	^{o}C	39.6	NC	NR	NR
Total Dissolved Solids	mg/L	578	NC	1,760	NR
Total Kjeldahl Nitrogen	mg/L	26.2	11.1	140	NR
Total Organic Carbon	mg/L	535	481	224	NR
Total Phosphorous	mg/L	10.1	3.3	NR	4 - 8
Total Residual Chlorine	ug/L	NR	0.37	NR	NR
TSS	mg/L	704	318	802	120 - 360
Turbidity	mg/L	224	NC	NR	NR

"NC" indicates that this information was not collected.
"NR" indicates that this information was not reported.
a. EPA used flow rates for the individual graywater sources to calculate a flow-weighted average to represent untreated graywater. Graywater sources include accommodations, galley, laundry, and food pulper (USEPA, 2008b).
b.(ADEC, 2001), (USEPA, 2008b)
c. (USEPA, 1999)
d. (Qasim, 1999)
e. (Metcalf & Eddy, 1991)
f. Measured as oil and grease.

Table 5 presents the average concentration and the range of concentrations for all untreated graywater samples collected unannounced by ADEC between 2001 and 2010 for 13 small cruise ships and five Alaska Marine Highway ferries as part of the Commercial Passenger vessel Environmental Compliance Program (CPVEC).[13] Examination of ACSI/ADEC untreated graywater data from small passenger vessels, including small cruise ships and ferries having between 50 and 250 passengers, shows analyte levels similar to graywater from large cruise ships.

[13] Alaska Statute (AS) 46.03.460-46.03.490, Commercial Passenger Vessel Environmental Compliance Program (CPVEC).

Table 5. Analyte Concentrations Measured in Untreated Graywater from Small Cruise Ships and Large Ferries in Alaska

Analyte	Average Untreated Graywater Concentration[a]	Range of Untreated Graywater Concentration[a]	Domestic Sewage[b]
Ammonia Nitrogen (mg/L)	8.8	<0.05 to 403	12 - 50
BOD_5 (mg/L)	326	<2 to 4,050	110 - 400
COD (mg/L)	592	<1.5 to 4,400	200 - 780
Fecal Coliform	608,000 (MPN/100 ml)[c]	<1 to 16,000,000 (MPN/100 ml)[c]	10,000-100,000 CFU/100 mL[d]
Hexane Extractable Material (mg/L)[e]	36	<5.3 to 320	50 - 150
pH (s.u.)	7.5	4.6 to 10.9	Not Reported
Total Phosphorous (mg/L)	7.7	<0.017 to 69	4 – 8
Total Residual Chlorine (mg/L)	11.2	<0.02 to 270	Not Reported
TSS (mg/L)	122	<0.65 to 2,570	120 - 360

a. Alaska Commercial Passenger Vessel Environmental Compliance Program (CPVEC). Values reported as zero were not included in the statistical calculation; values reported as “ND” in the database was replaced with the reported method detection limit and a “<” symbol placed on the minimum value in the range.
b. (Qasim, 1999)
c. Only fecal coliform values reported as MPN/100 ml were used in statistical calculations.
d. (Metcalf & Eddy, 1991)
e. Includes values measured as oil and grease.

In 2009, EPA collected untreated graywater characterization data from a variety of commercial fishing vessels and non-recreational and recreational vessels less than 79 feet in length (USEPA, 2010b). Specifically, EPA sampled graywater from eight vessels: five tugboats, a shrimper, a water taxi, and a recreational powerboat. These samples included graywater from sinks, dishwashers, and showers, as well as graywater samples from several mixed or unspecified sources. Graywater samples were analyzed for a range of analytes including pathogen indicators, classical pollutants, nonylphenols, metals, and nutrients.

Table 6 shows the average graywater analyte untreated graywater concentration and range of untreated graywater concentration data from this sampling program. The graywater data collected by EPA from these vessels is similar to that collected by ADEC from small passenger vessels (see Table 5 above). For example, the average BOD_5 concentration measured in graywater by ADEC from 2001 to 2010 was 326 mg/L, and the average BOD_5 concentration in graywater measured by EPA in 2009 was 430 mg/L.

Table 6. Analyte Concentrations Measured in Untreated Graywater from Fishing Vessels, Non-Recreational and Recreational Vessels Less Than 79 Feet in Length

Analyte	Average Untreated Graywater Concentration[a]	Range of Untreated Graywater Concentration[a]	Domestic Sewage[b]
Ammonia Nitrogen (mg/L as N)	1.3	0.19-4.5	12 - 50
BOD_5 (mg/L)	430	99-1,200	110 - 400
COD (mg/L)	1,000	180-4,000	200 - 780
Fecal Coliform (CFU/100 ml)	200,000	Nondetect-570,000	10,000-100,000[c]
Total Phosphorous (mg/L)	1.4	0.42-3.4	4 – 8
Total Residual Chlorine (mg/L)	0.12	Nondetect-0.11	Not Reported
TSS (mg/L)	52	14-81	120 - 360

Note: Nondetect concentrations were replaced with ½ of the reporting limit for calculating average concentrations, which can result in the average concentration being higher than the upper range.

a. USEPA Report to Congress: Study of Discharges Incidental to Normal Operation of Commercial Fishing Vessels and Other Non-Recreational Vessels Less Than 79 Feet. Average concentration based on eight vessels sampled by EPA.

b. (Qasim, 1999)

c. (Metcalf & Eddy, 1991)

The analyte concentrations shown in Table **6** above reflect the washing and bathing activities that generate graywater onboard these vessels. EPA found that BOD_5, oil and grease, (measured as hexane extractable material) and TSS all exceeded a Potential Hazard Quotient (PHQ)[14] threshold of 1, indicating that these pollutants in untreated graywater may have the potential to negatively impact receiving waters.

[14] PHQ divides the vessel's average concentration by a corresponding screening benchmark. For BOD_5 and oil and grease, the screening benchmark is the secondary treatment standards included in 40 CFR 133.

SECTION 3
CURRENT GRAYWATER MANAGEMENT PRACTICES

Graywater management strategies differ depending on regulatory regime, vessel type, size, and where the vessel discharge occurs. The following discussion provides the current graywater management strategies for vessels that have specific discharge requirements.

3.1 Graywater Management for Large Cruise Ships

Large cruise ships (authorized to carry 500 or more persons) that are pierside must either discharge to appropriate reception facilities, hold graywater and discharge when the vessel is underway, or treat graywater with a device to meet discharge standards.[15] Large cruise ships operating within 1 nm of shore must either hold graywater or treat graywater to meet the discharge standards. Large cruise ships operating between 1 nm and 3 nm from shore must either meet the discharge standards or discharge while the cruise ship is sailing at a speed of at least 6 knots.

Large cruise ships that operate in Alaskan waters must either treat their commingled sewage and graywater using AWTS[16] to achieve the required discharge standards, or hold their wastewater for discharge outside Alaskan waters. AWTS generally provide improved screening, biological treatment, solids separation (using filtration or flotation), and disinfection (using ultraviolet light) as compared to traditional Type II MSDs that use either simple maceration and chlorination, or biological treatment with gravity settling, followed by chlorine disinfection.

3.2 Graywater Management for Medium Cruise Ships and Large Ferries

Under the VGP, medium cruise ships (authorized to carry 100 to 499 people for hire) must use appropriate reception facilities for graywater while pierside, unless the vessel treats graywater with a device that will achieve the discharge standards. If appropriate reception facilities are not available and the vessel cannot treat graywater to the discharge standard, then the vessel must hold graywater and discharge while the vessel is underway and outside 1 nautical mile from shore. Large ferries[17] must use appropriate reception facilities for graywater when

[15] Discharge standards for graywater from large cruise ships (ships authorized to carry 500 or more persons) must meet secondary treatment standards for BOD_5, oil and grease, and pH as defined in 40 CFR 133.102. Concentrations of total residual chlorine may not exceed 10 ug/L and fecal coliform bacteria may not exceed 20/100 ml (geometric mean) during any 30-day period. USEPA, Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP). Version November 2010.

[16] Note that one of these AWTS, the Rochem system, treats low-concentration graywater (laundry and accommodations) separately from high-concentration wastewater (sewage and galley) using different processes (USEPA, 2006c). Specifically, low-concentration graywater is screened to remove fibers and hair, processed through reverse osmosis membranes to remove particulates and dissolved solids, and disinfected using ultraviolet light to reduce pathogens. However, because the reverse osmosis membranes generate a reject “concentrate” stream that requires further treatment (treated by the high concentration wastewater treatment process), graywater treatment is not completely independent of sewage treatment.

[17] With regard to graywater management, a “Large Ferry” means a ferry that is authorized by the Coast Guard to carry 250 or more people. USEPA, Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP). Version November 2010.

pierside, or hold the graywater if the vessel has the holding capacity and discharge the effluent while the vessel is underway and sailing at a speed of at least 6 knots, if feasible.

3.3 GRAYWATER MANAGEMENT FOR COMMERCIAL VESSELS ON THE GREAT LAKES

Under CWA section 312, graywater discharges generated onboard commercial vessels operating on the Great Lakes must be treated through an MSD prior to discharge, or be held in on-board storage tanks and discharged to shore-side facilities.

3.4 GRAYWATER MANAGEMENT FOR OTHER VESSELS

Personal contact with operators of small cruise ships, ocean-going cargo ships, and tug and tow boats shows that graywater is being managed on these vessels as well. Attachment B contains summaries of information collected during these telephone contacts. Table 7 lists the vessel classes contacted and summarizes the information gathered.

According to one small cruise line operating from Maine to Florida, vessels store graywater in onboard tanks if the vessels are located within a no-discharge zone (NDZ) and then discharge the graywater once they are outside the NDZ. This cruise line also pumps graywater shore-side when receiving facilities are available. According to the contact at the cruise line company, shore-side receiving facilities are available at some of the larger ports of call (e.g., Bangor, Maine), while others can truck collected graywater to shore-side receiving facilities (e.g., Troy, New York). The contact stated that many of the small ports their cruise ships enter have shore-side receiving facilities for small vessels such as yachts, but these dock areas are too small for their cruise ships. Therefore, they are forced to dock in locations where shore-side receiving facilities are not available. Conversely, other shore-side receiving facilities are located near docks only accessible by much larger vessels.

Two tugboat operators were contacted to determine how graywater is managed on these vessels. Tugboats operated by one operator on the Mississippi River generate accommodations, galley, and laundry wastewaters that are disinfected by routing the graywater through the disinfection portion of the vessels' Type II MSD. Each of this operator's tugs has been fitted with Owens KleenTank Type II MSDs for sewage treatment (biological treatment followed by chlorine tablet disinfection). This operator selected this graywater management practice for their 22 tugboats in anticipation of upcoming rules regarding graywater discharges. According to the operator, their tugboats were constructed in 2007 and included piping graywater through disinfection as a design requirement. Older tugs, such as those operated by a major tugboat operator in the Baltimore, Maryland and Chesapeake Bay region, discharge graywater overboard without treatment. These tugs do not include graywater piping that would allow the operators to collect and treat graywater prior to discharge. Graywater from this operator's tugs also includes wastewater from accommodations, galley (including dishwashers), and laundry.

Graywater management information was also gathered from personal contact with two container ship companies. According to one of these companies, graywater is generated by approximately 26 crew members in the galley, laundry, and accommodations, and is discharged overboard without treatment. The operator explained their vessels have limited holding capacity for graywater to allow for off-shore discharge (i.e., >3 nm), and most have not piped their sinks, showers, laundry, and galley to existing holding tanks. Graywater generation while in port is typically limited to galley water because container ships are only in port for approximately 12 hours to load and unload cargo.

Based on personal communication with a shipping company, other activities that generate graywater such as laundry and accommodations are performed when the vessel is well beyond 3 nm from shore.

Another shipping company's container ships can be in port for as long as seven days, which requires their vessels to store graywater in their after-peak ballast tank. According to the contact, their container vessels generate approximately 10 m^3/day (2,640 gal/day) of graywater from the galley, showers and sinks, and laundry, plus another 3 to 4 m^3/day of treated sewage while the vessels are in U.S. waters. According to the representative, storage of graywater in ballast tanks is not ideal because the tanks cannot be easily cleaned and there is a potential for hydrogen sulfide buildup that can be a serious health and safety risk when crew members need to enter the tanks. In addition, based on personal contact with the shipping company, storing graywater in ballast tanks while in port can limit vessel stability considering the amount of cargo that can be loaded.

Table 7. Vessel Operators Contacted to Discuss Graywater Management Practices

Vessel Operator	Vessel Class	Vessel Location and/or Port	Number of Vessels in Fleet	Typical Number of Persons Onboard (Passengers and Crew)	Graywater Management	Sewage Management
Vessel Operator 1	Fleet Boats and Tug Boats	Mississippi River	22	6 to 9	Chlorination prior to discharge	Biological, gravity settling, chlorine tablet disinfection (Owens KleenTank)
Vessel Operator 2	Small Cruise Ships	Northeast, Mid-Atlantic Coast, Columbia River	5	123	Direct discharge without treatment unless in NDZs	Maceration and chlorination
Vessel Operator 3	Container Ships	New York, Alaska, Hawaii, Florida, Puerto Rico	21	26	Direct discharge without treatment	Maceration and chlorination
Vessel Operator 4	Container Ships	Gulf Coast, Mid-Atlantic, Pacific Northwest	40	22	Hold in after-peak ballast tank	Maceration and Chlorination
Vessel Operator 5	Tug Boats and Articulated Tug/Barge Boats	Baltimore Area and Atlantic Coast	40	5 to 11	Direct discharge without treatment unless in NDZs	Maceration and chlorination
Vessel Operator 6	Medium Size Cruise Ships	Alaska and Caribbean	1	740	Treated through AWTS	Biological with membrane filtration and UV disinfection

AWTS: Advanced wastewater treatment system.

SECTION 4
GRAYWATER CONTROL STRATEGIES

As indicated in the tables above, graywater can contain constituent levels similar to raw domestic sewage and therefore discharging graywater without treatment may have the same environmental impacts as discharging raw domestic sewage without treatment. However, unlike domestic sewage, graywater can be discharged without treatment into U.S. waters, with the exception of Alaska and the Great Lakes. To determine if vessel MSDs and sewage treatment plants (STPs)[18] are applicable for treating graywater combined with sewage from all types of vessels, EPA contacted several system vendors (see Table 8 for the list of vendors contacted). Attachment B contains reports documenting information collected during these telephone contacts, and Attachment A includes published literature from a number of the vendor web sites. Specifically, discussions with the vendors were to determine the types of vessels that have or could later install treatment systems, the minimum number of passengers/crew required for the systems to operate properly, the types of wastewaters that could be treated, and the treatment system operation and maintenance requirements.

The treatment systems listed in Table 8 have received either a Certificate of Approval issued by the U.S. Coast Guard pursuant to CWA section 312[19] or a Certificate of Type Approval issued by a certifying body pursuant to MARPOL Annex IV[20] for the treatment of sewage only;[21] in some cases, the treatment systems have received both a Certificate of Approval and a Certificate of Type Approval. Based on vendor claims, and in several cases supported by analytical monitoring data from large AWTS, some treatment systems can produce effluent with sufficient quality for continuous discharge in Alaskan waters (to meet Title XIV and 2008 VGP requirements) or within 1 nm of the U.S. shore (to meet 2008 VGP limits). Although some vendors claim their systems have the capability to treat both sewage and comingled sewage and graywater, the MSD type-approval testing procedures performed in the laboratory do not use sewage comingled with vessel graywater. Instead, based on personal contact with an MSD testing laboratory, MSD type approval testing uses either domestic sewage, which consists of both sewage and graywater, or sewage collected from “honey dipper” trucks, which may contain far less graywater, depending on the source (See Attachment B). Table 9 lists MSD type approval standards and discharge standards for various U.S. and international regulations.

Although all the vendors contacted can supply MSDs certified to either the CWA section 312 standards or the MARPOL standards, many may not be achieving the type certification

[18] STPs are certified to meet the MARPOL Annex IV effluent standards and performance tests adopted by the Marine Environment Protection Committee (MEPC) in either of the following resolutions: MEPC.2(VI) on December 3, 1976, or MEPC.159(55) on October 13, 2006.

[19] See 33 U.S.C. § 1322(b); 40 CFR Part 140 (EPA performance standards) and 33 CFR Part 159 (U.S. Coast Guard MSD regulations).

[20] See MARPOL Annex IV; Resolution MEPC. 159(55), Resolution MEPC.2(VI).

[21] On October 13, 2006, the IMO’s Marine Environment Protection Committee (MEPC) adopted revised effluent standards and performance tests for STPs. See resolution MEPC.159(55). The revised standards and testing requirements apply to STPs installed onboard ships on or after January 1, 2010. Ships with STPs installed prior to that date may continue to use equipment certified to the previous standards.

standard once installed on the vessel.[22] For example, the manufacturers of some treatment systems stated their systems are not equipped with any type of continuous effluent monitors, and CWA section 312 does not contain provisions requiring routine effluent sampling or monitoring to verify compliance with the standards once the units are installed onboard. The manufacturers also stated that their systems are not typically interfaced with the vessels' control systems, so crew members would need to physically inspect all mechanical systems (e.g., pumps, blowers) to verify that they are actually operating. In addition, the MSDs having biological treatment use chlorine tablets for disinfection. Disinfection with tablets leads to a more widely varying level of residual chlorine than other disinfection methods. Therefore, the natural variability in wastewater characteristics would result in discharging fecal coliform bacteria or residual chorine above the Title XIV or IMO Resolution MEPC 159(55) standards. Poor effluent quality produced by such systems has been documented in sampling data collected by ADEC.[23] None of the vendors contacted by EPA claimed they required any graywater addition or other process water addition to operate their sewage treatment systems. However, based on EPA's experience with MSDs, process water is commonly added to provide flushing water needed to move sewage through the vessels' piping system, and/or to provide a source of chloride for the maceration and chlorination type MSDs.

More data and information would be useful to determine the effectiveness of MSDs used for treatment of combined sewage and graywater. Additional data characterizing the quality of untreated graywater from a variety of vessel types would assist in better characterizing potential environmental impacts from this discharge. Data collection which would improve EPA's understanding of graywater characteristics and its treatability include:

- Collecting effluent performance data for MSDs treating graywater or both sewage and graywater to determine whether the systems are actually performing to their original USCG type certification,

- Collecting influent and effluent sampling data from AWTS that are operating on existing vessels with relatively small numbers of passengers/crew to verify system performance claims, and

- Gathering additional cost data to determine the economic impacts to vessel owners and operators if both sewage and graywater is treated to either USCG or IMO MEPC 159(55) standards.

[22] Vendor MSD are typically the same as those installed on small ships that were sampled by ADEC. Sampling results show that these systems were not achieving their type certification standards (ADEC 2006, ADEC 2007).

[23] Alaska Department of Environmental Conservation, Commercial Passenger Vessel Compliance Program 2001 to 2010 Small Ship Wastewater Sampling Results (ADEC 2006, ADEC 2007).

Table 8. Vessel Sewage Treatment System Vendors Contacted to Discuss Graywater Treatment Claims

Vendor	Treatment System Name	Treatment System Description	Wastewaters Treated	System Certifications	Target Analytes	Vessel Classes Currently Using Treatment System	Minimum Number of Passengers and Crew Required for Operation
Vendor 1	EVAC	Membrane Bioreactor Treatment Without Disinfection	Sewage, Commingled Sewage and Gray Water, and Graywater Only	IMO Resolution MEPC 159(55)	BOD COD TSS Fecal Coliform	Naval Vessels Oceanographic Vessels Small Cruise Ships	25[a]
Vendor 2	Hamann AG	Biological Treatment with Dissolved Air Flotation and Ultraviolet (UV) Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD COD TSS Fecal Coliform	Mega-Yachts Small Passenger Vessels	10
Vendor 3	FAST System	Fixed-Media Biological Treatment with Gravity Clarification and Chlorine Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD COD TSS Fecal Coliform	Tug Boats Tow Boats Off-shore Platforms Crew Boats	10
Vendor 4	Hamworthy Super Trident	Biological Treatment with Gravity Clarification and Chlorine Disinfection and Dechlorination	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD COD TSS Fecal Coliform	Large Cruise Ships Small Cruise Ships	21[b]
Vendor 5	CleanSea	Moving Bed Biological Reactor with Dissolved Air Flotation, Tertiary Filtration and UV Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	Ammonia BOD COD TSS Fecal Coliform	Large Cruise Ships	1,000

Table 8. Vessel Sewage Treatment System Vendors Contacted to Discuss Graywater Treatment Claims

Vendor	Treatment System Name	Treatment System Description	Wastewaters Treated	System Certifications	Target Analytes	Vessel Classes Currently Using Treatment System	Minimum Number of Passengers and Crew Required for Operation
Vendor 6	KleenTank	Biological Treatment with Gravity Clarification and Chlorine Tablet Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD_5 COD TSS Fecal Coliform	Drilling Vessels Ferries Lift Boats Tow Boats Tug Boats	3
Vendor 7	Red Fox	Biological Treatment with Gravity Clarification and Chlorine Tablet Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD_5 COD TSS Fecal Coliform	Ferries Drilling Vessels Pleasure Yachts Small Cruise Ships Tug Boats Tow Boats	1
Vendor 8	Rochem	Membrane Bioreactor With UV Light Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD_5 COD TSS Fecal Coliform	Mega-Yachts Large Cruise Ships Small Cruise Ships	TBD
Vendor 9	Scanship	Biological Treatment with Dissolved Air Flotation and UV Disinfection	Sewage and Commingled Sewage and Graywater	IMO Resolution MEPC 159(55) and CWA Section 312[c]	BOD_5 COD TSS Fecal Coliform	Ferries Large Cruise Ships Off-Shore Platforms	100

TBD: To be determined.

a. Sewage only based on a vacuum collection system.

b. Sewage only based on gravity collection system.

c. 33 U.S.C. Section 1322(a)(6), a marine sanitation device includes “any equipment for installation on board a vessel which is designed to receive, retain, treat, or discharge sewage, and any process to treat such sewage.” Under CWA section 312, vessels equipped with installed toilet facilities are prohibited from operating on the navigable waters (which include the 3-mile territorial seas), unless the vessel is equipped with an operable MSD certified by the Coast Guard to meet applicable performance standards. 33 U.S.C. § 1322(h)(4); see also 40 CFR Part 140 (EPA MSD performance standards) and 33 CFR Part 159 (U.S. Coast Guard MSD regulations).

Table 9. Vessel Sewage Standards under Various U.S. and International Regimes

Analyte	CWA Performance Standards For Type II MSDs(40 CFR 140; 33 CFR 159)	IMO Resolution MEPC.2 (VI)	IMO Resolution MEPC 159(55)	Title XIV: Certain Vessels Operating in Alaska (33 CFR 159, Subpart E)
BOD_5 (mg/L)		Geometric mean ≤ 50	Geometric mean ≤ 25	30
COD (mg/L)			≤ 125	
Fecal Coliform (CFU/100 ml)	≤ 200 per 100 mL	Geometric mean ≤ 250 per 100 mL (fecal coliform; most probable number)	Geometric mean ≤ 100 per 100 mL [a]	20
Residual Chlorine (mg/L)		To the degree practicable	0.5	0.01
TSS (mg/L)	≤ 150	Geometric mean ≤ 50 (shore-side testing)	Geometric mean ≤ 35	30
pH (s.u.)			6 to 8.5	6 to 9

USCG: United States Coast Guard.
IMO: International Maritime Organization.
a. Thermotolerant coliforms.

To further document the performance of type-certified vessel sewage treatment systems, EPA compiled ADEC effluent sampling data from five Alaska Marine Highway vessels. Each vessel was fitted with a traditional Type II MSD that treats comingled sewage and graywater. Table 10 shows ADEC's average treatment system effluent data collected between 2006 and 2010. The data show that treatment system effluent TSS concentrations achieve the 33 CFR 159 standards on four of the five vessels; however, only one vessel achieved the fecal coliform standard. Because maceration and chlorination systems can add up to 10 times the volume of process water compared to the amount of wastewater being treated (Griffiths, 2009), it is unclear whether the TSS results shown in Table 10 are from actual treatment or from dilution by process water. These data clearly show that, although traditional Type II MSDs and other similarly designed and operated systems are type-certified, they may not be meeting the applicable standards once they are placed into service on vessels.

Table 10. Average Treated Effluent Data For Five Alaska Marine Highway Vessels Treating Comingled Sewage and Graywater

	Vessel				
	Columbia	**Kennicott**	**Malaspina**	**Matanuska**	**Taku**
MSD Type	Maceration/ Chlorinatin	Macerator/ Chlorination	Macerator/ Chlorination	Macerator/ Chlorinator	Maceration/ Chlorination
Manufacturer	Omnipure	Orca	Omnipure	Omnipure	Effluent Technology
Total Passengers and Crew	691	804	550	548	412
Wastewaters Treated	Comingled Sewage and Graywater	Comingled Sewage and Graywater	Comingled Sewage and Graywater	Comingled Sewage and Graywater	Comingled Sewage and Graywater
Analyte	**Average Effluent Concentrations[a]**				
Ammonia (mg/L)	27.3	0.7	17.0	13.2	6.2
BOD_5 (mg/L)	124	19	179	129	105
COD (mg/L)	641	610	875	691	868
Fecal Coliform (CFU/100 ml)[b]	249,000	70	1,344,000	889,000	67,500
Total Chlorine (mg/L)	5.5	4.4	6.2	6.8	4.7
TSS (mg/L)	95	28	80	100	180

a. ADEC Commercial Passenger Vessel Compliance Program 2006-2010. For values reported as either "ND" or zero in the database, the value was replaced with the reported method detection limit.
b. Only fecal coliform values reported as CFU/100 ml were used in statistical calculations.

EPA also contacted treatment vendors having systems that use a combination of treatment technologies such as filtration, biological treatment and/or disinfection (systems similar to those found on large cruise ships operating in Alaska).[24] As indicated in Table 11, these systems, found primarily on large cruise ships, achieve significant reductions in key analytes as compared to traditional Type II MSDs using similar technologies. For example, ADEC collected effluent data in 2006 and 2007 for two Alaska passenger vessels using Red Fox Type II MSDs (biological treatment, gravity setting, and chlorine disinfection) treating sewage (ADEC, 2006 and 2007). The effluent data from these two vessels show BOD_5 concentrations ranging between 171 and 273 mg/L, and TSS concentrations ranging between 120 and 603 mg/L. Comparing these effluent concentrations to the effluent concentrations shown in Table 11 clearly shows that the AWTS provide superior performance.

[24] AWTS approved for continuous discharge in Alaska waters have been documented in the literature to achieve the effluent discharge standards for BOD_5, TSS, fecal coliform, residual chlorine, and pH specified at 33 CFR 159, Subpart E. See Alaska Department of Environmental Conservation, Commercial Passenger Vessel Compliance Program 2006 Large Ship Wastewater Sampling Results.

Table 11. Large Cruise Ships AWTS Influent and Effluent Concentrations and Percent Removals

Analyte	Average Large Cruise Ship AWTS Influent Concentration[a]	Average Large Cruise Ship AWTS Effluent Concentration[b]	Overall AWTS Percent Removal[a]
Ammonia (mg/L as N)	78.6	36.6	58 to 74
BOD_5 (mg/L)	526	7.99	>99
COD (mg/L)	1,140	69.4	>93 to 97
Fecal Coliform (CFU/100 ml)	103,000,000	14.5	>99
Oil and Grease[c] (mg/L)	95.6	5.74	>91 to >96
Total Chlorine (mg/L)	NA	0.34	NC
Total Phosphorous (mg/L)	18.1	5.05	41 to 98
TSS (mg/L)	545	4.5	>99

Source: (USEPA, 2008b)
The ">" symbol indicates a minimum level of removal.
NA: Data not available.
NC: Not calculated.
a. Based on data collected by EPA in 2004 and 2005.
b. Based on data collected by ADEC/USCG 2003 to 2005; data collected by EPA in 2004 and 2005; and data collected through EPA's 2004 cruise ship survey.
c. Oil and Grease measured as Hexane Extractable Material (HEM).

Although some vendors stated their AWTS were too large to place on small cruise ships and passenger ferries, other vendors do provide units that could handle smaller passenger numbers such as mega-yachts. For example, through personal communication with two manufacturers, both claim that their systems can be installed on small vessels. In addition, one vendor claims their system can treat sewage, commingled sewage and graywater, or graywater only. This was the only vendor contacted that claimed their system could treat graywater only; however, they qualified that one of the graywater sources must be from the vessel galley to provide sufficient BOD_5 for biological treatment (All other AWTS vendors stated that some sewage was required to provide sufficient BOD_5 for biological treatment). According to the vendor, their system can be installed on vessels with as few as 25 crew/passengers. The system has been installed on a U.S. Navy oceanographic vessel; however, this vendor did not provide the number of crew or the name of the vessel.

Another vendor, has a biological treatment system with dissolved air floatation for solids separation that can be installed on vessels having as few as 100 passengers and crew. The Scanship system can treat commingled sewage and graywater, including wastewater from the food pulper system. According to the vendor, the company is also currently testing a nitrification and denitrification unit that has been integrated into its existing treatment system on the Norwegian Star, a large cruise ship that operates in Alaska. The system on the Norwegian Star is currently being tested on voyages between Los Angeles and Mexico's Baja peninsula in order to have the system ready for the 2011 Alaska cruise season. The vendor has also stated it is considering retrofitting the nitrification and denitrification unit on all its existing treatment systems and any new cruise ship installations.

SECTION 5
SUMMARY

Graywater from vessels contains analytes with concentrations similar to those in raw domestic sewage. Under CWA section 312, only commercial vessels on the Great Lakes are required to consider graywater as sewage and therefore treat graywater through an MSD prior to discharge. In Alaska, Title XIV and Alaska state law require that medium and large cruise ships either hold sewage and graywater for discharge outside Alaska waters, or treat graywater and sewage to EPA's CWA section 312 performance standards for Type II MSDs when between 1 and 3 nm from shore. Medium and large cruise ships within 1 nm of shore must treat sewage and graywater to meet stringent standards for fecal coliforms and total chlorine, and meet secondary treatment standards for BOD_5, TSS and pH (found at 40 CFR 133.102).

Alaska statute (AS) 46.03.462(e), administered by ADEC as part of the CPVEC, allows small passenger vessels[25] in Alaska to discharge graywater without treatment as long as the vessel has developed and implemented an approved Best Management Practice Plan. The 2008 VGP requires that all medium and large cruise ships in U.S. waters treat graywater if discharged within 1 nm of shore, or hold and discharge graywater outside 1 nm when the vessel is traveling at 6 knots. Under the 2008 VGP, commercial vessels outside of the Great Lakes and Alaska can discharge graywater without treatment with some notable restrictions. With the exception of large and most medium size cruise ships, and some large container/tank ships, many commercial vessels face challenges containing near-shore graywater discharges. The reasons why such vessels must discharge within 3 nm include: 1) insufficient capacity to hold graywater, 2) piping systems that discharge graywater overboard immediately upon generation, and 3) vessel operations exclusively within 3 nm of shore, thus providing no opportunity to discharge outside 3 nm. For example, graywater generated onboard a cargo/container ship is typically piped directly overboard, even though the average sewage storage capacity for these vessels is nearly 8 days (Chamber of Shipping of America, 2010). Based on personal communication with a cruise line company, small cruise ships typically have some capacity to store graywater while operating in NDZs, but these vessels spend the majority of their time operating within 3 nm of shore (See Attachment B). Most tugboats discharge graywater directly overboard without treatment and operate almost exclusively within 3 nm of shore. Large cruise ships, however, do have the capacity to hold graywater for 1 to 2 days as evidenced by their ability to hold all wastewaters while sailing in areas such as Glacier Bay in Southeast Alaska, where discharges are generally prohibited under their concession contracts with the National Park Service. Large cruise ships also periodically operate away from shore, providing opportunity to discharge stored graywater outside U.S. waters.

Although processing graywater commingled with sewage through a system that has been type-certified to meet either the CWA section 312 performance standards or the IMO Resolution MEPC 159(55) standards appears to be a viable option, there are concerns regarding the ongoing performance of the systems once in service. Data collected by ADEC for Alaska Marine Highway ferries that treat combined sewage and graywater indicates that traditional treatment system designs (e.g., maceration and chlorination) are often not meeting the applicable vessel

[25] A small vessel has 50-249 overnight passengers as defined in AS 46.03.490(7).

sewage standards. In fact, because sampling of effluent from type-certified treatment systems is not required outside of Alaska, ongoing performance data from vessels operating in other areas of the country are not available.

Discussions with vendors of AWTS approved for large cruise ships that continuously discharge in Alaskan waters found that some have developed units that can be installed on vessels having as few as 25 persons. Specifically, this vendor has developed a membrane bioreactor that can treat not only sewage and commingled sewage and graywater, but also graywater only (provided graywater includes galley wastewater). Another vendor has a biological treatment system with dissolved air flotation and UV disinfection that can be used on mega-yachts with as few as 10 persons. Unfortunately, no “real-world” data exists on the actual shipboard performance for these systems.

Other vendors that claim their devices can achieve IMO Resolution MEPC 159(55) discharge standards are relying only on their initial type certification data to support their claims. None of these systems is equipped with continuous monitoring equipment (e.g., for turbidity), disinfection is performed with simple chlorine tablets, no operating and maintenance labor is required, and the only available ongoing performance data from Alaska shows poor effluent quality from these devices. In addition, these vendors do not follow up with performance sampling of installed units, because any sampling is at the discretion of the vessel operator.

SECTION 6
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ATTACHMENT A:

PUBLISHED LITERATURE FROM VENDOR WEBSITES

The AHEAD TANK Type II Marine Sanitation Device is a biological Aerobic (bacteria and air) Sewage Treatment System. Liquid and solid wastes are removed from the water by bacteria naturally contained in sewage. The AHEAD TANK consists of three treatment stages; aeration, clarification and chlorination. In the aeration chamber (Stage 1), the bacteria grows and multiply using the sewage as their food supply. This action reduces the quantity and size of the solid matter. In the clarification chamber (Stage 2), the bacterial floc is separated from the treated water. The treated water is clear and free from solids; however, the liquid must be disinfected prior to discharge overboard to kill any disease-causing bacteria. Disinfecting is accomplished in the Chlorination Chamber (Stage 3) flow through these three chambers is caused by direct displacement. When new sewage flows into the aeration chamber, an equal volume flows into the clarification chamber. This volume, in turn, displaces an equal volume from the clarification chamber into the chlorination chamber, and overboard. No internal sewage pumps are necessary.

AERATION

Sewage is aerated as soon as it enters the treatment system and mixes with the aerated liquid already in the aeration chamber. EPDM Air diffuser injects air near the bottom of the aeration chamber so that the sewage remains in a state of aerobic decomposition. This aerated liquid contains the bacterial sludge that reacts with the sewage to start the reduction process. The movement created by the injected air helps mix the sewage with the bacterial sludge and prevents sludge and sewage solids from settling to the bottom. The air discharged from the surface of the liquid in the aeration chamber is vented to the atmosphere through a vent line connection.

CLARIFICATION

The liquid displaced from the aeration chamber flows into the clarification chamber for further treatment. Some of the suspended material will settle out into the bottom of the chamber below where it will return to the aeration chamber. The remaining sludge and waste material is removed as the liquid flows upward through the biological filter media. Bacteria grows on the surface of the media and produces a sticky, slimy film that traps small particles of waste. The bacteria on the surface of the filter media then consumes the trapped waste. By the time the liquid reaches the top of the filter media it has passed through several layers of bacteria, ensuring that the sludge and waste removal process is completed. Any floating solids are returned to the aeration chamber by means of an air lift pump. Clean water accumulates here until it is displaced into through the crossover line into the chlorination chamber.

CHLORINATION

The water flowing out of the crossover line is directed through a chlorine tablet feeder (Model AT-6T & AT-12T only) coming in contact with the chlorine tablets before entering the chlorination chamber where it is held for a residence time sufficient to complete the disinfectant stage of the process.

Headworks BIO™
CLEANSEA®

INTEGRATED SHIPBOARD WASTEWATER TREATMENT

Headworks BIO CleanSea shipboard wastewater treatment systems deliver effluent quality surpassing the world's most stringent marine discharge standards with the lowest lifecycle treatment costs in the industry.

Integrating premium marine-grade components, CleanSea technology delivers environmental capabilities specifically designed to meet the tough requirements of long-term shipboard operation.

Headworks BIO™
CLEANSEA®

FEATURES

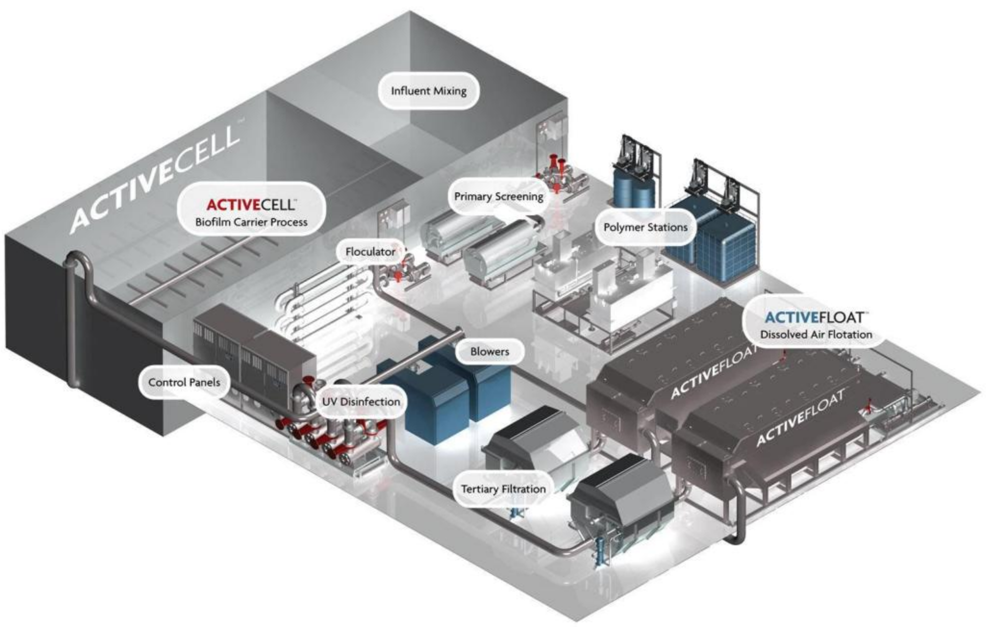
- Advanced black, grey, laundry and galley water treatment processes
- Highest level of customer support in the industry
- Premium marine-grade components
- Compact and space efficient design
- Available with total system redundancy
- Fully automated operation with remote monitoring
- Optional ultra filtration module for technical water re-use.

BENEFITS

- Lowest lifecycle treatment costs in the industry
- Very low energy and chemical use
- Easy to operate with minimal maintenance
- Process resiliency independent of influent fluctuations
- Reliable, continuous operation with maximum system uptime
- Superior quality, safe effluent for direct discharge

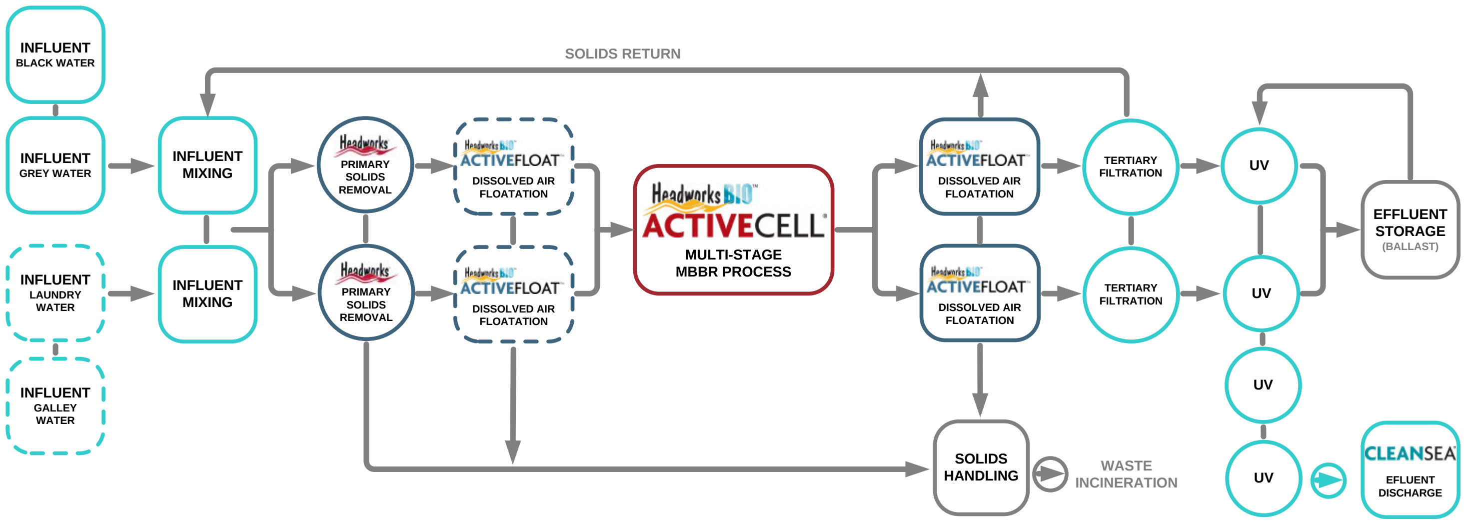
Parameter	Guaranteed Performance	MEPC 159(55) Limit	ADEC 2010 Limit
BOD_5 (mg/l)	< 25	< 25	< 30
TSS (mg/l)	< 35	< 35	< 150
Fecals (CFU/100 ml)	< 14	< 100	< 14
Free Chlorine (mg/l)	< 0.01	< 0.5	< 0.01
pH	6.5 – 8.5	6 - 8.5	6.5 - 8.5
Ammonia (NH_3-N) (mg/L)	< 28	N/A	< 28
Copper (µg/l)	< 87	N/A	< 87
Zinc (µg/l)	< 360	N/A	< 360
Nickel (µg/l)	< 43	N/A	< 43

CleanSea is designed to efficiently treat any blend of marine wastewater streams including grey water streams from accommodation, galley, decanter reject water, and laundry sources as well as black water.



CLEANSEA®

TYPICAL PROCESS FLOW DIAGRAM



CLEANSEA® Integrated Process	
Influent Mixing	Controlled filling from collection to aerated mixing balances pH and ensures consistent influent characteristics; this optimizes CleanSea performance and reduces costs and consumables.
Headworks **Primary Solids Removal**	Primary solids are removed from the influent streams utilizing a fine wedgewire screen; solids are discharged to solids handling processes at a dry weight concentration of ~10%.
Headworks BIO ACTIVEFLOAT™ DAF	In systems where high load streams such as galley water and food waste reject water is processed, a pre-DAF is added prior to the bioreactors to provide additional pre-treatment.
Headworks BIO ACTIVECELL®	The ActiveCell process employs self-regulating biofilm carrier technology; the ActiveCell system operates in a multi-stage configuration with three reactors for BOD removal and nitrification.
Headworks BIO ACTIVEFLOAT™ DAF	Suspended particulates are removed following the ActiveCell biofilm carrier process via ActiveFloat dissolved air flotation (DAF) technology, optimized for shipboard operation
Tertiary Filtration	Low maintenance, self-cleaning filters achieve total suspended solids removal < 25 mg/L
UV Disinfection	High intensity ultra-violet lamps achieve disinfection providing extended coliform destruction; the multi-stage UV array maximizes final treatment performance without chemical use.

Headworks Bio Canada

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Victoria, BC V8W 1HS
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250.381.8850
hw@heaworksusa.com

ZODIAC

Zodiac, mastering the elements.

Evac MBR
New waste water treatment

Introduction

Evac has more than 30 years of experience in the design, manufacture and marketing of wastewater collection and treatment equipment for the shipbuilding industry.

Evac offers a complete range of products for wastewater collection and treatment:

- Sewage treatment plants
- Vacuum collecting units
- Vacuum toilets

Evac's vacuum collecting units and treatment plants are the natural choice for shipbuilders. Because of the fact that the conventional sewage treatment plants do not meet requirements of the new IMO MARPOL resolution MEPC.159(55) Evac has developed a new treatment technology called Evac membrane bioreactor (MBR). Evac has a proven track record of reliable deliveries, worldwide support and tested effluent results.

Regulations

The Evac MBR is certified according to the new IMO MARPOL resolution MEPC.159(55) and meets all other existing regulations. This enables vessels equipped with the Evac MBR to operate all around the world – including environmentally sensitive areas.

The IMO testing procedure outlined in MEPC.159(55) requires that the influent concentration of total suspended solids should be no less than 500 mg/l. In order to ensure that it will work under all conditions, the Evac MBR has been tested with over 2100 mg/l of total suspended solids in the influent concentration. This makes it the ideal solution for the treatment of black water collected by vacuum, a solution that requires no dilution water.

Advantages:

- Extremely low running costs and energy consumption
- Resistant to clogging and fouling of the membrane
- Expected lifetime of membranes more than 10 years
- Small footprint
- Low sludge yield
- No continual chemical consumption
- Disinfection is not required
- Dilution water is not required

Discharge parameters	IMO MARPOL MEPC 159 (55)	Navy NIAG 2015 Target	Florida	Evac MBR test results
TSS, mg/l	35	50	40	< 5
BOD5, mg/l	25	15	30	< 5
COD, mg/l	125	-	-	< 30
Faecal/Thermotolerant coliforms, cfu/100 ml	100 thermotolerant coliforms	100	0	below detection limits
Residual Chlorine, mg/l	< 0.5 mg/l	0	0,5	no disinfection
pH	6,0-8,5	-	-	within limits

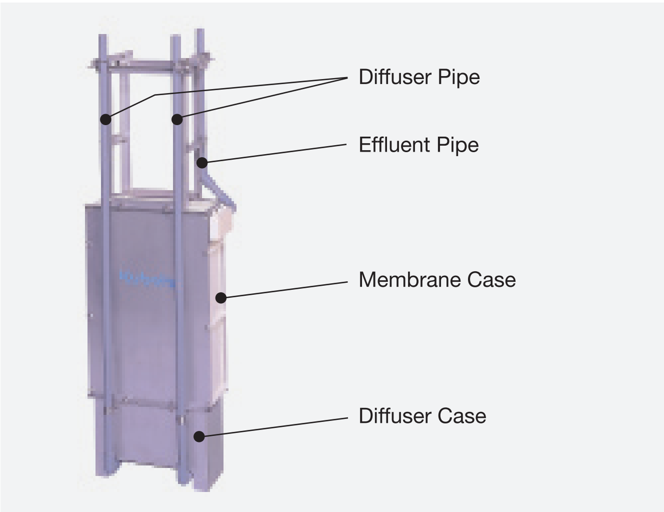
Construction

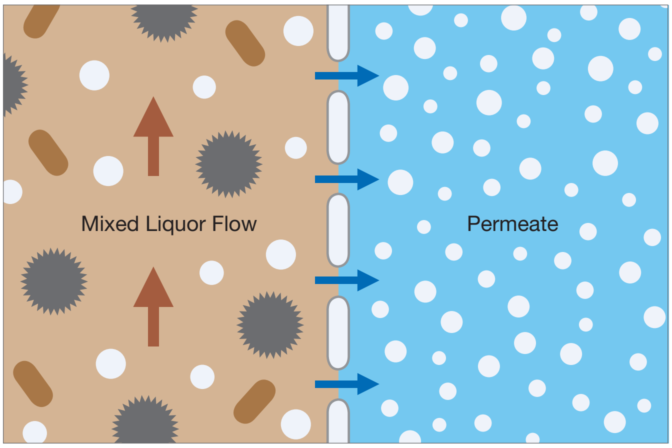
The Evac MBR is delivered as one complete, factory tested unit with all process steps mounted on one skid.
The Evac MBR process is fully automated and controlled through a PLC.
Evac uses high quality Kubota membranes. Kubota membranes are used in more than 1,400 plants worldwide.

Evac membrane bioreactor MBR 8

The Structure of the Submerged Membrane Unit

The Membrane Unit consists of a Membrane Case and a Diffuser Case. The Membrane Case accommodates multiple Membrane Cartridges, which are connected to a manifold with transparent tubes. The Diffuser Case has a Diffuser Pipe inside. Each Membrane Cartridge can be pulled out for maintenance.

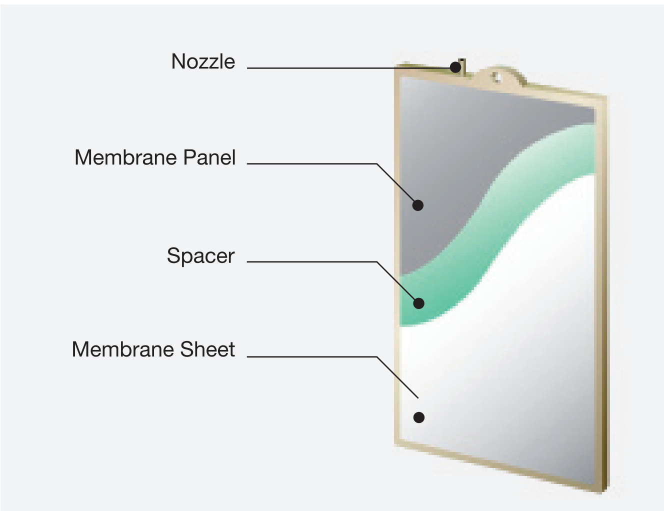




Membrane

The Structure of the Membrane Cartridge

The membrane sheets are ultrasonic-welded on both surfaces of the membrane panel. They are made from chlorinated polyethylene with a nominal pore size of 0.4µm. Treated water permeates through the membrane sheets and internal spacers to come out via the nozzle.



TYPENPRÜFUNGSZEUGNIS
für Abwasser-Aufbereitungsanlagen
Certificate of Type Approval for Sewage Treatment Plants

Vacuum collecting and treatment from a single source supplier

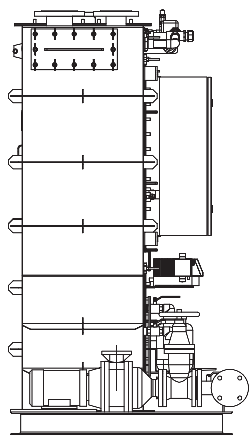
The Evac MBR can be delivered as a combined sewage treatment plant with integrated vacuum collecting unit and vacuum toilets. Using Evac as the single source supplier guarantees:

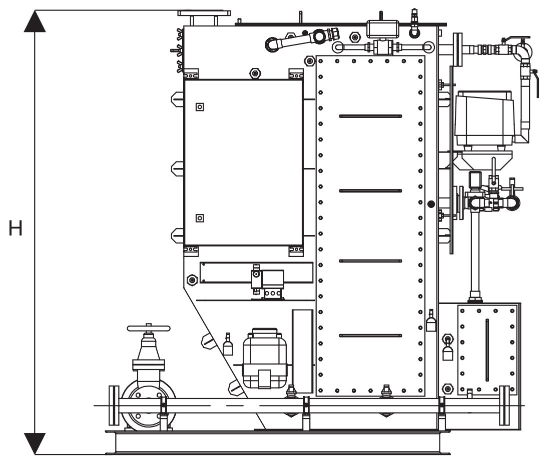
- easy trouble free installation and start-up
- the reliable functioning of the whole equipment chain – the vacuum collection and the treatment.

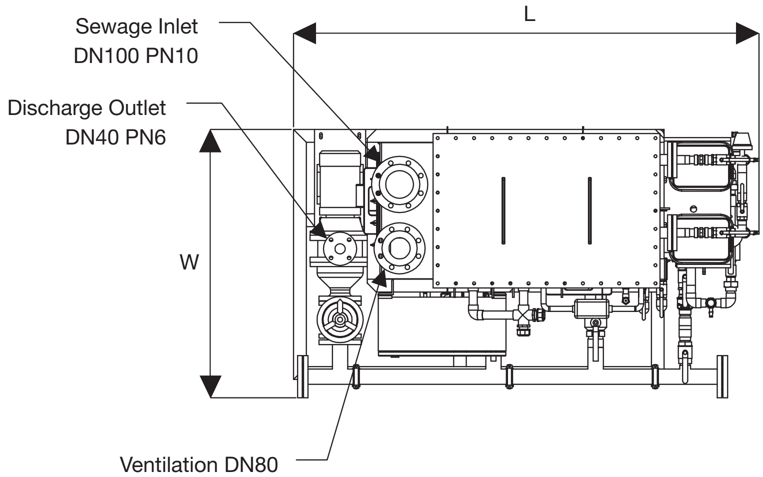
The advantages of a vacuum system:

- lower water consumption
- piping is not dependent on gravity
- smaller bore piping, reduced installation time, reduced weight
- reduced size of holding tanks and sewage treatment plants
- no smells
- lower deck toilets without pumps

Evac standard MBR overall dimensions







Evac standard MBR

MODEL	No. of People (vacuum)*	No. of People (gravity)*	Hydraulic loading, l/day	Organic loading, kg BOD5/day	Dry weight, kg	Wet weight, kg	Dimensions L x W x H
MBR 8	25	21	1500	0,75	580	1800	1960x1050x1970
MBR 16	50	42	3000	1,50	780	3100	2460x1385x1970
MBR 24	75	63	4400	2,25	900	4150	2480x1720x1970
MBR 32	100	84	5900	3,00	1020	5170	2500x2055x1970

* For black water
Evac reserves rights for modifications.

Further information about our company is available at our website www.evac.com.

Principle of operation

The Evac MBR is based on proven, very low maintenance membrane bioreactor technology, capable of filtering out particles as small as bacteria. Its compact footprint makes it ideal for retrofitting to existing vessels as well as for installation on new ships.

Pre-treatment:

Foreign objects must be removed before the treatment process. Efficient pre-treatment using screens also reduces organic loading, increasing the efficiency of treatment.

Biological process:

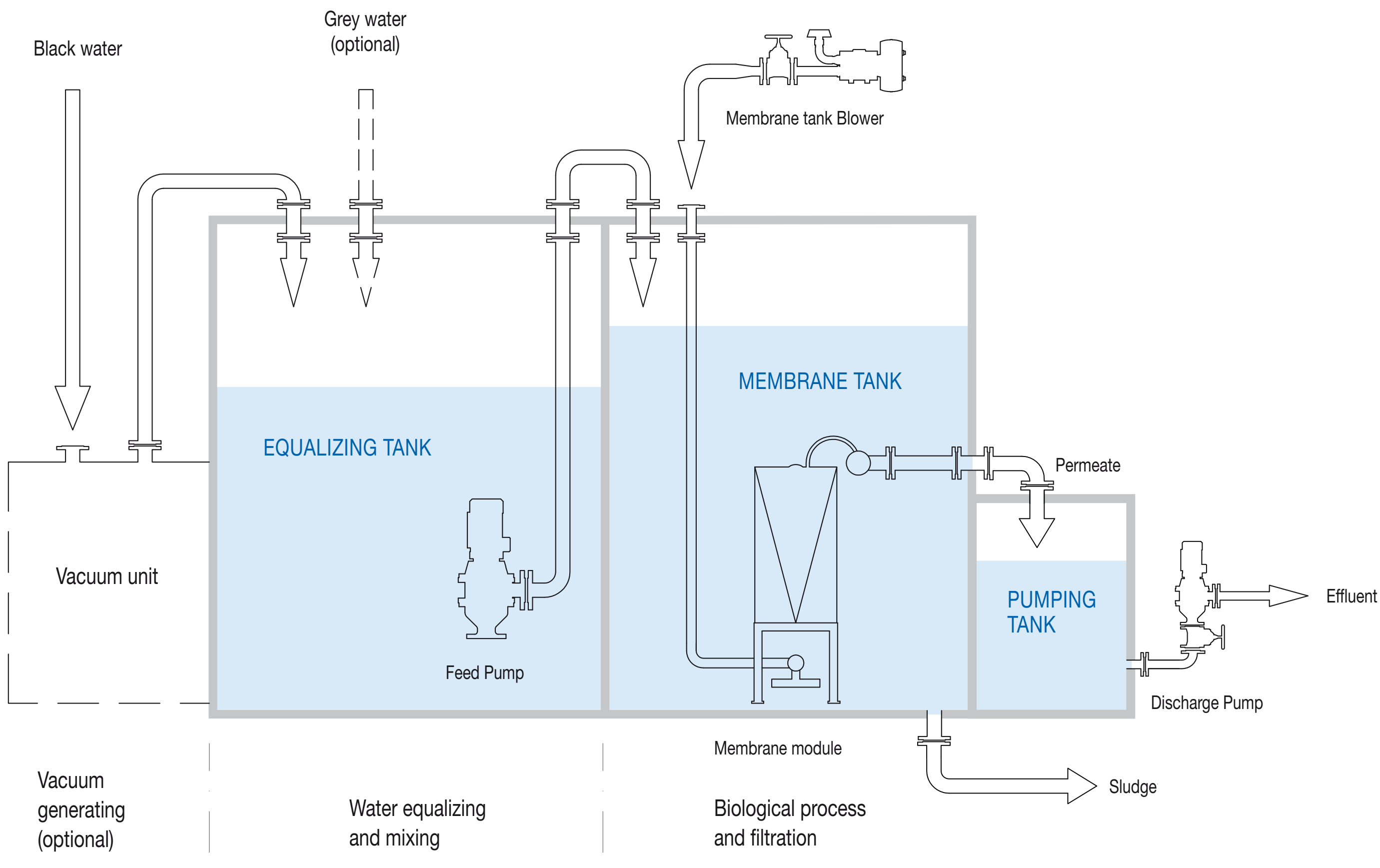
Organic waste is removed from the water during the treatment process. Organics are turned into carbon dioxide, water and biomass (MLSS). The Evac MBR is designed to operate on elevated concentrations of biomass. Oxygen for the biomass is supplied through membrane module air diffusers, whilst the oxygen simultaneously cleans the membranes with turbulent cross flow.
All bioprocesses produce surplus sludge and part of the biomass is removed from the process. The concentration of biomass in the Evac MBR is monitored and sludge removal is automated.

Membrane filtration:

Clean water is separated from the biomass by membrane filtration. Evac MBR membranes are submerged flat-sheet type membranes. The Evac MBR does not require any back-flushing or constant chemical cleaning, making it the most economical and maintenance-friendly membrane solution. The pressure difference for the membrane filtration is only around 30 mbar; such a small amount of pressure acting on the membranes guarantees them an extremely long lifetime.

Aeration from the bottom creates an upward flow of mixed liquor in between the membrane cartridges. This prevents the membrane surface from fouling, and as a result the membranes only need to be cleaned twice a year.

The treated water does not need any further disinfection and can be discharged directly into the sea.



ZODIAC

Commercial Marine Equipment
Part of Zodiac Marine & Pool

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Evac is the most experienced supplier of vacuum toilets and wastewater management solutions for the ship building industry.

Evac is capable of delivering a comprehensive system for the collection, treatment and discharge of both black and grey water. The total wastewater concept gives the shipyard and ship owner a reliable and integrated system with economical operation costs.

Evac products are typically most suitable for ships over 2 000 dwt, with a crew and/or passengers of 25 or more. This ship range covers cruise liners, coastal and ocean going cargo ships, naval vessels, car and passenger ferries, river cruisers, ro-ro vessels, submarines, rigs and mega yachts.

Over the last years Evac has made considerable investments in research and development on the problems of marine wastewater treatment. This has resulted in four treatment product ranges: advanced waste water treatment solutions, advanced black and black/grey water treatment solution, biological sewage treatment solutions and physical/chemical sewage treatment plants.

With our combination of know-how in both waste water treatment and vacuum collection, Evac can always provide the most suitable technical solution for the ship.

At the moment there are about 8 000 ships in operation with more than 0,5 million Evac toilets, thousands of vacuum units and hundreds of sewage treatment plants.

Evac technologies are IMO and USCG certified.

Specializing in Sewage Treatment Systems for the Marine and Offshore Industries. All **FAST**® (**F**ixed **A**ctivated **S**ludge **T**reatment) units are fully certified by USCG under U.S. and IMO regulations. ▶ More

Easy to install, **FAST**® units are ideal for everything from small commercial vessels to large cruise ships and ore carriers. They ship direct to the customer as factory-built assemblies, as factory-built modules, and as kits for installation into existing tanks. These reliable and trouble-free **FAST**® units are already capable of meeting the next generation of sewage regulations.

Products & Applications

The LX-Series - This new economical and lightweight modular design is ideal for small commercial vessels. It is strong, corrosion resistant and will fit under the stairway of a tug engine room.

The M-Series - Modular steel units will handle crews of up to 60 persons and will fit into shaft alleys and other spaces with low headroom and restricted access.

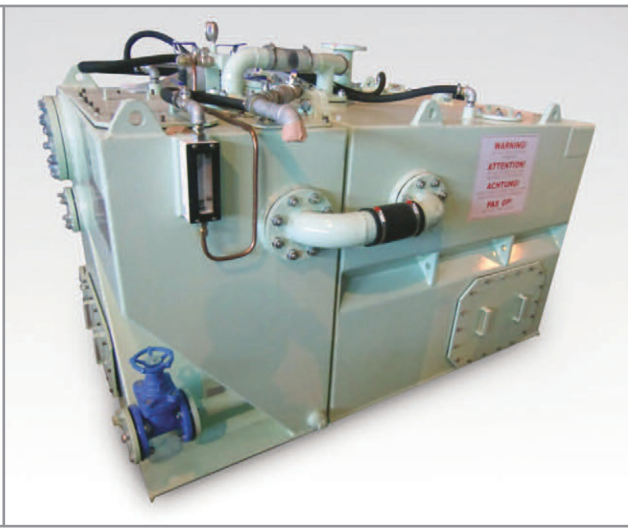
The MX-Series - Assembled versions of the M-Series, these compact package units are ideal for workboats, dredges, offshore vessels and structures, and other commercial vessels.

The D-Series, DX-Series & DV-Series - For larger crews, these flexible designs offer the ultimate in strength, corrosion resistance and performance. They are available in bolt-together modular form for installation aboard existing vessels, such as ferries, off-shore platforms and ore carriers.

0038/YY

Retrofit STA-C and ST-C Series

Super Trident Sewage Treatment Plant



Hamworthy is the world's leading manufacturer of marine sewage treatment plants. For over three decades our Super Trident sewage treatment plants have been widely regarded as standard specification on all vessels.

Hamworthy's STA-C/ST-C Super Trident sewage treatment plants were one of the first plants in the market to be granted type approval in meeting the new IMO MEPC.159(55) standard, which employs more stringent black and grey water effluent quality treatment guidelines. All sewage treatment plants installed on existing ships on or after 1 January 2010, and on new ships whose keels are laid on or after this date, must meet the new MEPC.159(55) guidelines.

The retrofit range has been specifically designed to reduce the cost of installing sewage treatment equipment into existing vessels. Each size in the retrofit range is built up from three separate water tight tanks connected by external piping, aiding installation. The dimensions of each component has been arranged to permit its transportation through standard vessel access ways.

Standard features

- **IMO & MED certificate authorised by U.K. M.C.A.**
- **Modular construction**
- **Single power supply input point**
- **Minimal maintenance requirement**
- **Solids handling Hamworthy centrifugal discharge pump**

Optional features

- **Standby compressor**
- **Standby discharge pump**

Operating Principle

Aeration compartments
Sewage enters the first of two aeration compartments via the soil inlets and a coarse screen before being thoroughly mixed and aerated by the aerators located at the bottom of the tanks. The aerobic bacteria and micro organisms break down the organic waste material into mainly carbon dioxide, water and inert material and produce new bacteria cells and organisms. This mixture is displaced by incoming sewage into the settling compartment. Air, which provides the oxygen for the bacteria and micro organisms is supplied by a rotary compressor to the fine bubble aerators which are easily removable through the side or end of the tank for maintenance.

Settling compartment
This section is designed to precipitate all solid material to the bottom of the hopper as activated sludge which is then returned by air lift back to the aeration compartments where it is mixed with the incoming raw sewage. The clear supernatant liquid is then displaced into the disinfection compartment. An outlet weir is situated at the centre of the settling compartment. This controls the flow of supernatant into the disinfector.

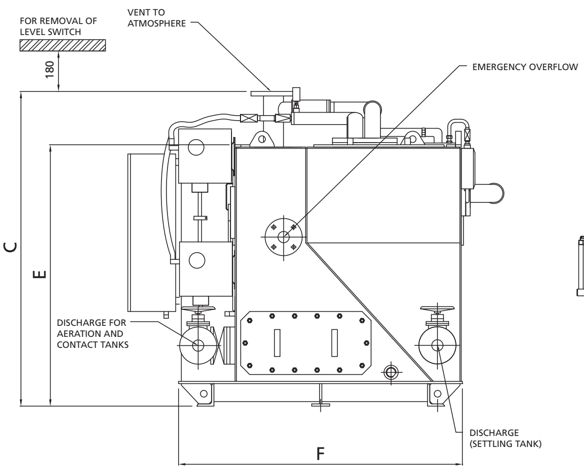
Disinfection compartment
Chemical disinfection and dechlorination are dosed into the effluent to produce a clean, safe, effluent suitable for discharging at sea.

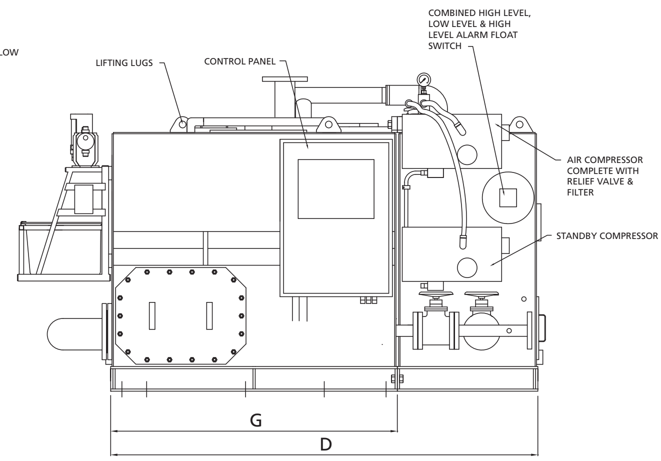
Standard	Coliform	Suspended solids	BOD (5)	COD	pH	Residual Chlorine
MEPC.159(55) 01/01/2010 (new)	100 Geom mean	Land test: 35 Geom mean On board test: 35* Geom mean	25 Geom mean	125 Geom mean	6~8.5	Best Tech Practice <0.5

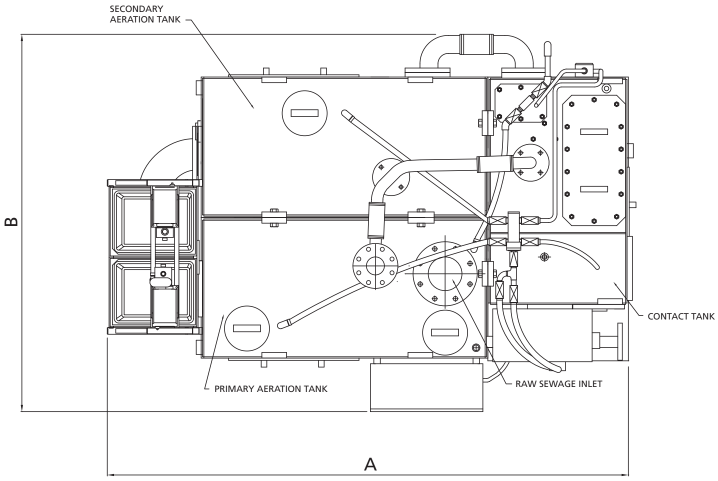
Hamworthy

Model No.	IMO Cert. Litres/Day	No. of people (under normal gravity collection conditions)	Dimensions (mm) A	B	C	D	E	F	G
ST2AC-(R)	3260	21	2318	1678	1398	1900	1174	1265	1290
ST4AC-(R)	5960	41	2518	1835	1847	2100	1624	1415	1415
ST6AC-(R)	9200	65	3024	2035	1937	2550	1724	1615	1765
ST8AC-(R)	12200	86	3324	2135	2037	2850	1824	1715	2015

Model No.	Size of aperture through which unit will pass when separated into three parts with panel, transfer tubes, chlorine tablet magazine and vent tubes attached.	Size of aperture through which unit will pass when separated into three parts with panel, transfer tubes and studs, chlorine tablet magazine and vent tubes and covers removed.
ST2AC-(R)	867 x 1371	655 x 1220
ST4AC-(R)	942 x 1821	730 x 1670
ST6AC-(R)	1042 x 1921	830 x 1770
ST8AC-(R)	1092 x 2021	880 x 1870







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Fleets Corner, Poole, Dorset BH17 0JT. England.
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e-mail: info@hamworthy.com
website: www.hamworthy.com/sewagetreatment

a subsidiary of Hamworthy plc

Hamworthy

The Humphrey
Type II Marine Sanitation Device
Sewage Treatment Systems for 3-75 crew.

Marine sewage treatment systems can be complicated or they can be simple. The ***Humphrey*** Type II Marine Sanitation Devices (MSD) are designed for simplicity, are engineered with common sense, and will provide years of trouble-free service.

The ***Humphrey*** Type II MSD's are onboard sewage treatment systems that are fully certified by the USCG and are IMO* approved. Each ***Humphrey*** unit exceeds the effluent standard set by Pollution Act Federal Water (33 CFR159) and carries our Certification Number - to ensure absolute compliance with Federal laws.

Because of the possibility of future change in the law, the ***Humphrey*** is designed to yield effluent actually higher in quality than currently required by the USCG.

The ***Humphrey*** is:

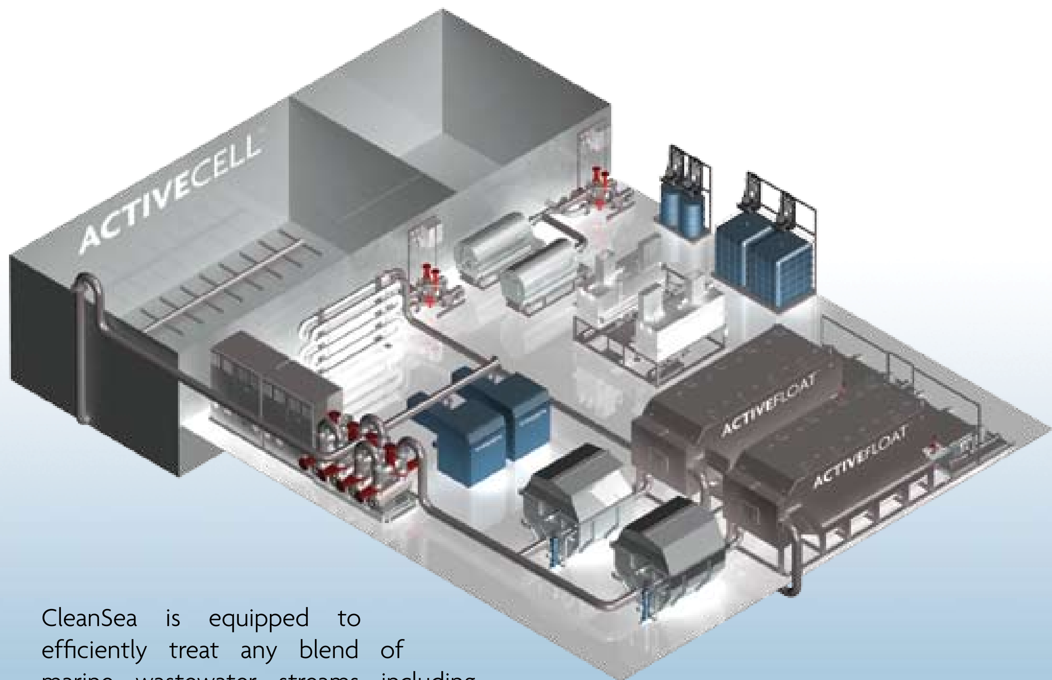
- **Flexible.** By choosing to use a modular design instead of a large, bulky, all-in-one unit, we give you ease of installment with greater placement flexibility. ***Humphrey*** units can be stacked for compactness or installed remotely from each other. The system is flexible so you don't have to take your boat apart. Most systems can be installed in a matter of hours.
- **Workable.** ***Humphrey*** components are usually small enough to pass through existing passageways - facilitating easy installation and minimizing costly down time.
- Lightweight. If weight is a critical constraint in your application the ***Humphrey*** offers you the best solution.
- **Non-corrosive**. By choosing to use non-corrosive materials (including a special space age polymer yielding strength and durability, we offer you an MSD truly compatible with harsh marine environment.
- **Cost Effective**. ***Humphrey*** systems effectively treat waste for pennies a day per person. And with few moving parts, there are fewer opportunities for maintenance problems. Replacement parts are readily available and very inexpensive.
- **Customer Friendly**. By choosing to go with field-proven technologies from the start, we have been able to concentrate on how the product works for our customer. From listening to our customers we have upgraded, refined, and expanded the product into today's user friendly model line which exceeds USCG requirements for effluent qualify.

HYDROXYL CLEANSEA®

INTEGRATED SHIPBOARD WASTEWATER TREATMENT PROCESS

Hydroxyl CleanSea shipboard wastewater treatment systems deliver effluent quality surpassing the world's most stringent marine discharge standards with the lowest lifecycle treatment costs in the industry.

Integrating premium marine-grade components including Hydroxyl patent-pending processes, CleanSea technology delivers environmental capabilities specifically designed to meet the tough requirements of long-term shipboard operation. Every CleanSea system is carefully designed and integrated within each vessel layout. This ensures optimum functionality within space constrained decks.



CleanSea is equipped to efficiently treat any blend of marine wastewater streams including grey water streams from accommodation, galley, food reject water, and laundry sources as well as black water.

HYDROXYL CLEANSEA®

FEATURES

- Advanced black and grey water treatment processes
- Highest level of customer support in the industry
- Premium marine-grade components
- Compact and space-efficient design
- Total system redundancy
- Fully automated operation with remote monitoring

BENEFITS

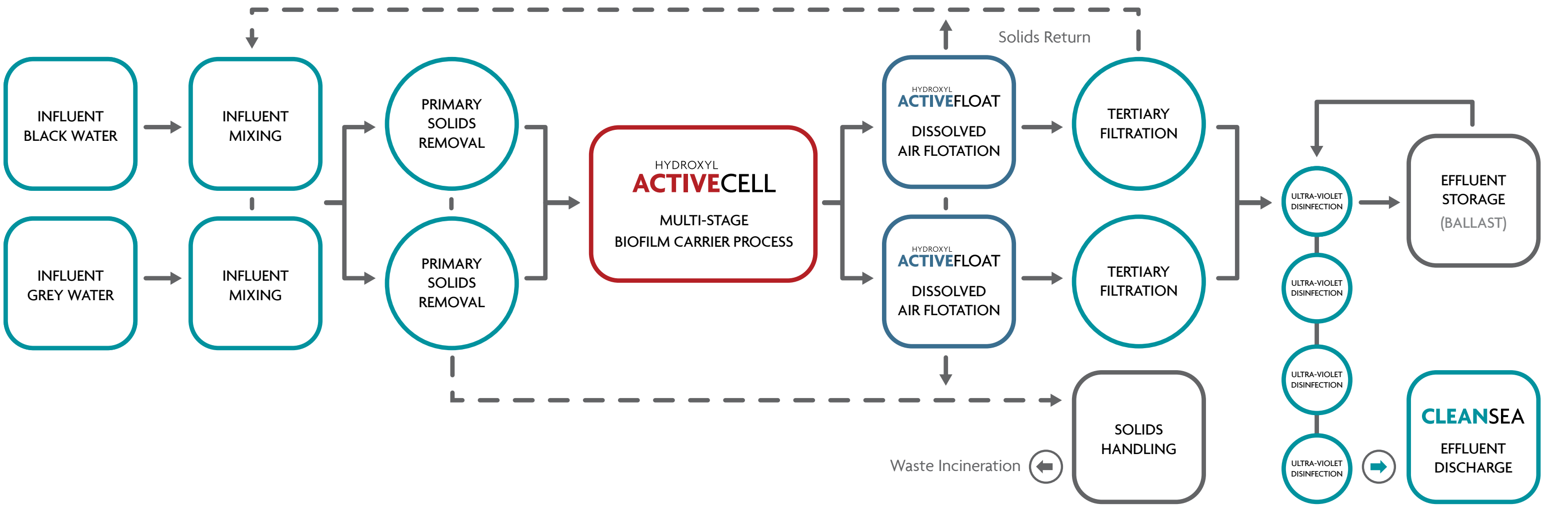
- Low lifecycle treatment costs
- Reduced energy and chemical use
- Easy to operate with minimal maintenance
- Process resiliency independent of influent fluctuations
- Reliable, continuous operation with maximum system uptime
- Superior quality, safe effluent for direct discharge

HYDROXYL CLEANSEA®

PROCESS FLOW DIAGRAM

"In Hydroxyl, Royal Caribbean has an advanced technology solution and business partner that enables us to continue to demonstrate leadership in environmentally responsible operations within our industry."

Peter Fetten
Royal Caribbean Vice President of Newbuilding & Fleet Design



Water Results™
< 15 mg/L BOD
< 15 mg/L TSS
< 10 CFU/100mL

CLEANSEA® Integrated Processes

Influent Mixing	Controlled filling from collection to aerated mixing balances pH and ensures consistent influent characteristics; this optimizes CleanSea performance and reduces costs and consumables.
Primary Solids Removal	Primary solids are removed from the influent streams utilizing a fine wedgewire screen; solids are discharged to solids handling processes at a dry weight concentration of ~10%.
HYDROXYL ACTIVECELL™	The ActiveCell process employs self-regulating biofilm carrier technology; the ActiveCell system operates in multi-stage configuration with three reactors for enhanced biokinetics.
HYDROXYL ACTIVEFLOAT™	Suspended particulates are removed following the ActiveCell biofilm carrier process via ActiveFloat dissolved air flotation (DAF) technology, optized for shipboard operation.
Tertiary Filtration	Low maintenance, self-cleaning filters achieve total suspended solids removal <15 mg/L; results exceed stringent Alaska State discharge standards by over 50%.
UV Disinfection	High intensity ultra-violet lamps achieve disinfection providing extended coliform destruction; the multi-stage UV array maximizes final treatment performance without chemical use.

HYDROXYL
Water Results™

Hydroxyl Systems Inc.
26 Bastion Square
Victoria, BC V8W 1H5 Canada
T 250.381.8850 | F 250.381.8870
info@hydroxyl.com

Steve DePoli, AScT
Vice President, Marine
T 250.381.8850 | C 250.514.1431
sdepoli@hydroxyl.com

www.hydroxyl.com

Owens Manufacturing & Specialty Company was the FIRST to make a U.S.C.G. certified marine sanitation device (MSD). Whether you operate a single ship, or an entire fleet, our marine units are perfect for all of your sewage/waste treatment requirements. Simple operation, easy maintenance, long lasting reliability and optimum effluent compliance have kept Owens KLEEN TANK "The Preferred Choice" for more than 35 years.

Owens offers custom design and manufacturing as well as stock units. We use state of the art technology and superior manufacturing practices to deliver a product that is IMO and U.S.C.G. certified. Replacement parts are readily available.

The Owens KLEEN TANK is self-contained and delivered to your site ready for installation and operation in your vessel.

Features/Benefits

- Easy four point maintenance plan
- Easy access covers
- Easy access/non-corrosive valve controls
- Low maintenance disinfection system
- Constructed of carbon (corrosion protected) or stainless steel
- Stainless steel weir basket - self cleaning
- Regenerative TEFC blower - quiet
- Float controlled effluent pump
- Patented floating skimmer
- Alarm system
- Stock availability of units and parts
- Full line of complementary products

The Redfox Environmental Marine Model has received Bureau Veritas certification for IMO Resolution MEPC 159(55). The IMO Marine Environmental Protection Committee resolution applies to all sewage treatment systems installed onboard on or after January 1, 2010. The Marine Model is designed, manufactured and tested to comply with MEPC 159(55) effluent standards.

This wastewater treatment technology has been utilized by Red Fox for over (25) years. This design is utilized on vessel applications.

The process used by the MSD involves the same three steps as the conventional unit, but the clarifier operates under a fluid head pressure allowing flocculation and settling of the solids in the clarification chamber to occur even when the vessel is in motion:

Coarse Screening: As the influent enters the sewage treatment unit, it passes through a bar strainer. This strainer will catch any large trash such as rags, plastic bags, etc., and prevent it from entering the system.

Aeration: Supports naturally occurring bacteria that eliminates the waste.

Clarification & Settling: Causes the separation of the bacteria sludge from the treated water.

Disinfection: Eliminates the presence of any living bacteria before discharge of the effluent into the environment.

RedFox Model	Persons/ Black Water	Persons/Black & Gray Water
RF-100-M	5	2
RF-200-M	10	4
RF-350-M	18	7
RF-500-M	25	10
RF-750-M	38	15
RF-1000-M	50	20
RF-1500-M	75	30
RF-2000-M	100	40
RF-2500-M	125	50
RF-3000-M	150	60
RF-3500-M	175	70
RF-4000-M	200	80

RF-4500-M	225	90
RF-5000-M	250	100
RF-5500-M	275	110
RF-6000-M	300	120
RF-7500-M	375	150
RF-9000-M	450	180

Waste Water System

The international focus on discharging waste water in coastal waters is increasing. New standards for discharge and various regulations are driving the cruise industry to process all waste water onboard. To meet new demands and future requirements, Scanship offers a complete system for waste water treatment.

Scanship's waste water system is designed to treat all types of maritime waste water, thus managing the rapid and significant load variations. The system reduces the need of large holding capacity onboard and increases the operational flexibility. The waste water system has been developed from proven land based technology, cleverly re-designed for maritime industry.

Traditional waste water plants onboard only treat black water. This represents less than 10% of the total hydraulic load and less than 15% of the actual pollution. Today Scanship treats 100% of the waste water in nearly the same space as the traditional black water treatment plants, making this the most compact solution available. In many cases our systems eliminates in-port discharge fees.

Scanship AWP
Purification beyond requirements!

A proven technology for clean discharge in the maritime world

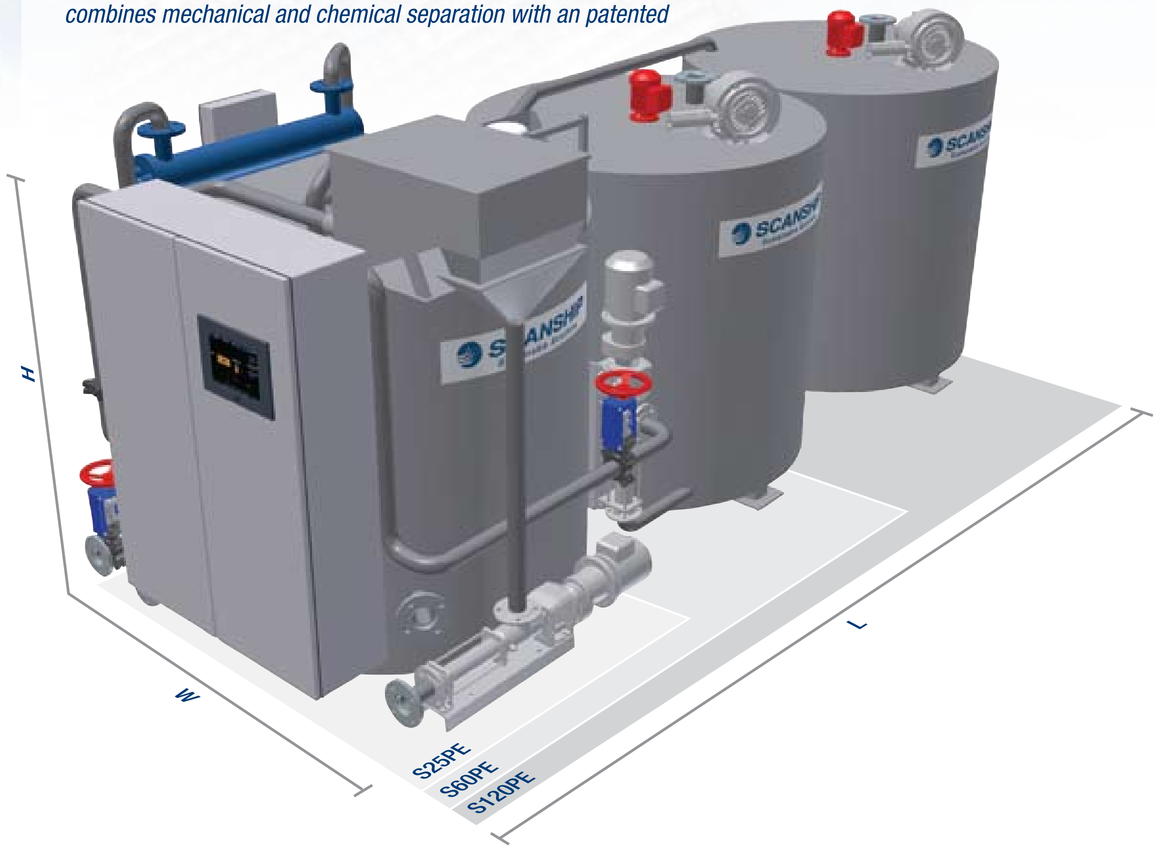
Based on long time experience in the Cruise Industry, installing and operating more than 25 large advanced wastewater purification systems for ship-owner NCL and RCCL in Alaska, a new compact edition is available for all marine markets.

Scanship does not stop at todays effluent requirements set forth in the Alaska Murkowski Bill and IMO Marpol MEPC 159/55. We exceed the standards to make your ship the greenest in the worlds fleet! We guarantee the treated effluent from the Scanship AWP to be in accordance to the Alaska Standard for Continuous Discharge and all classification societies Cleanship Superior Notation.

Scanship AWP removes organic matters, suspended solids, bacteria and nutrients such as phosphorus and nitrogen. The technology combines mechanical and chemical separation with an patented biofilm process with BOD removal and Nitrification/Denitrification. All bacteria is removed from the effluent with advanced UV technology.

Scanship AWP treats all wastewater sources onboard, such as black and grey water, accomodation grey, laundry water and galley water inclusive food waste rejects. The process is robust, easy to operate without the hassels of clogging (none membrane technology).

The process provides a crystal clean effluent discharge. As a reference, Cruiseliners equipped with Scanship AWP systems has obtained continous discharge permits in Hawaii and Alaskan waters, and in numerous European ports such as Venice and Oslo ever since 2003.



Model	Capacitiy pax/crew	Load m3/d	Load kg BOD5/d	Installed Power KW	Dimensions (m) W	Dimensions (m) L	Dimensions (m) H	Weight (kg) Dry	Weight (kg) Wet
S25PE	30	5	6	8	1,8	1,9	2,0	900	3200
S60PE	60	15	12	12	1,8	3,3	2,0	1200	5800
S120PE	120	24	24	18	1,8	4,8	2,0	1600	8500

Scanship can deliver systems for all capacities, the largest Scanship AWP systems in operation treats wastewater from 6 000 people onboard.

SCANSHIP
Sustainable Solutions

www.scanship.no

Scanship as, Rambergveien 3, 3115 Tønsberg, Norway, Ph: +47 33 01 64 00 • Fax: +47 33 01 64 01 • E-mail: post@scanship.no

ATTACHMENT B:

SUMMARIES OF INFORMATION GATHERED IN TELEPHONE CONVERSATIONS

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Marine Equipment Division of Smith and Loveless, Inc. –FAST SYSTEMS
Sunset Hills, MO

Contact: David Predau
Phone: 314 645 6540
Date: December 10, 2010

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to Smith and Loveless.

Overview:

The marine equipment division of Smith and Loveless, Inc. manufactures and sells the Fixed Activated Sludge Treatment (FAST) System; a U.S. Coast Guard (USCG)[1] and IMO Resolution MEPC 159(55)2 approved Type II MSDs. Systems can be installed on vessels having as few as 6 passengers and crew and are designed to treat sewage (blackwater), but can treat commingled blackwater and graywater. According to Mr. Predau, 99 percent of their installations are for treatment of blackwater only. FAST systems have been installed on tow boats, tug boats, crew boats and off-shore platforms. According to Mr. Predau, graywater sources could include showers and sinks, but not galley due grease problems, or any graywater containing constituents that may be toxic to the system such as Lysol. The system treats fecal coliform bacteria, TSS, BOD and COD. The system is not designed to treat ammonia or phosphorous.

FAST systems are fixed-bed biological treatment. According to Mr. Predau, sewage enters an aeration tank where the microorganisms grow on fixed media within the aeration tank. Accumulated solids from biological treatment settle by gravity into the bottom of the aeration tank where they are removed every 3 months. Effluent from clarification flows through a disinfection system containing chlorine tablets.

According to Mr. Predau, the system requires little to no operator attention. Water pumps and the airlift pump operate continuously, and there are not other moving parts. The system is typically not tied to the ship's controls to determine if all mechanical systems are in operation. There is no monitoring equipment (e.g., turbidity meters, etc.) or other mechanisms to verify effluent quality. No effluent monitoring is performed to verify compliance according to Mr. Predau since the system is type certified using a 10-day test, and on-board monitoring is therefore not required. The system can withstand a couple of weeks without flow. FAST systems have a relatively small foot-print according to Mr. Predau and can be retrofit on existing vessels to replace more common maceration and chlorination systems.

1 USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.
2 IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, 0.5 mg/L TRC, and pH 6 to 8.5.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
EVAC - ZODIAC Systems
Washington State

Contact: Shirley Fredrick
Phone: 815 639 7725
Date: November 18, 2010

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI, however we are not able to receive CBI information at this time, and that data that is not claimed as CBI can be used publicly without notice to EVAC.

Overview:

After explaining why ERG was contacting EVAC, Shirley asked if EPA was going to require numeric effluent limits for graywater like USCG does for sewage systems, when that may happen, and if existing treatment systems would be "grandfathered". We stated we were contractors and could not provide answers to those questions. Instead we provided her with Robin Danesi and Ryan Albert's contact information if she wished to discuss the VGP program with them.

EVAC manufactures a membrane bioreactor (MBR) certified to IMO Resolution MEPC 159(55)[1] standards. EVAC is currently in the process of getting US Coast Guard certification for the MBR for use in US waters. The system is not certified for continuous discharge in Alaska, although the discharge testing data indicates the system would provide sufficient effluent quality for continuous discharge in Alaska. Systems can be installed on vessels having a minimum of 25 passengers with a vacuum toilet system or 21 passengers with a gravity system. The system can treat only sewage, commingled sewage and graywater, or graywater only. If graywater only is treated, one source must be galley wastewater to provide sufficient BOD/organics for the microorganisms; however, pretreatment must be performed on galley water to remove grease and a macerator should always be installed as well. Systems are sized based on the specific influent BOD to the MBR and are therefore custom built for each particular vessel.

There are approximately 300 EVAC MBRs operating throughout the world, however only 2 are being used in the United States; on a military vessel (TAG 66) and the other on an oceanographic vessel. The systems have been installed on cruise ships and other non-US military vessels. Shirley will email a list of vessel types and possibly contacts which the EVAC has been installed throughout the world. EVAC systems may require a pretreatment that includes screening to remove items that can not be macerated. Pretreatment systems are sold separately. Treatment begins with initial maceration and flow/loading equalization. Effluent from equalization enters the two aerated membrane tanks where biological treatment removes BOD. Effluent from the tank flows through membranes suspended in the tank. The membranes are constantly scoured by the air bubbles in the tank, so physical cleaning is only required a couple times per year. Sludge from the system is removed every 3 weeks to prevent excessive mixed liquor solids. Sludge is placed in a separate tank for proper disposal. It is estimated that in a blackwater only system, 3% will become sludge. There is no disinfection system for the EVAC. According to Shirley, the membrane systems produce an effluent that is free of bacteria. Shirley directed ERG to the certification literature which indicted fecal coliform bacteria in the effluent from the 14-day IMO certification test were below detection.

1 IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, 0.5 mg/L TRC, and pH 6 to 8.5.

According to Shirely, the system does require operator attention. She indicated 2-3 hours per week to monitor sludge/solids levels. Shirley also stated the system requires a constant flow with sufficient BOD for the organisms, and shutting down the system is not recommended. She indicated that it can take 2 weeks to grow sufficient bacteria for the system to be restarted. The system can be tied to the ships controls so the operators can verify the systems are operating. Systems are equipped with alarm systems to verify they are operating within the hydraulic parameters. There is no monitoring equipment (e.g., turbidity meters, etc.) or other mechanisms to verify effluent quality that she was aware of. However, the system detects pH and self-adjusts as needed.

EVAC does not install equipment on vessels, but instead sells the certified systems to the ship builder/contractors. They do assist with the initial system start-up but do not do follow-up system verification after startup. Shirley stated the systems are large and a significant footprint and weight bearing requirement is needed. Retrofits can be done; however, it is typically done when the vessel is doing other types of major reconstruction.

Shirley stated we could have an operating manual, however it can not be shared since it is CBI. ERG stated we can not take CBI information at this time and to not send the manual.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Hamann AG – Filwatec US
Oakland Park, Fl

Contact: Rudy Goeth
Phone: 954 537 4735
Date: November 18, 2010

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI, however we are not able to receive CBI information at this time, and that data that is not claimed as CBI can be used publicly without notice to Hamann AG.

Overview:

Hamann AG manufactures a U.S. Coast Guard (USCG)[1] and IMO Resolution MEPC 159(55)[2] approved Type II MSD. The system is not certified for continuous discharge in Alaska. Systems can be installed on vessels having between 10 and 800 passengers to treat commingled sewage and graywater. The system can not treat only sewage, or only graywater. Hamman AG Type II MSDs have been installed primarily on mega yachts and small passenger vessels. None have been installed on ferries or cargo ships. The new IMO Resolution MEPC 159(55) certified systems have not yet been installed on cruise ships, but they can be if a cruise ship has an interest. Graywater sources include showers and sinks, but not galley due grease problems. The system treats bacteria, TSS, and BOD. It is not designed to treat ammonia or phosphorous.

Hamann systems are physical/biological. Sewage is initially macerated before entering a tank similar to a dissolved air flotation unit. Air bubbles in the tank cause solids to float while providing dissolved oxygen for biological treatment. Floated sludge from the system is collected and placed into a separate tank where it is either discharged outside 12 nm or shore-side. The system does not use membrane filters or chlorine. Effluent from the aeration tank passes into a UV light disinfection chamber. Sea water does enter the system for pump seals and other processes (process water) which does dilute the wastewater. Rudy had no idea how much seawater is actually added to the system as process water.

According to Hamann, the system requires little to no operator attention. Pumps, sludge skimmers, compressors and blowers operate continuously. The system can be tied to the ships controls so the operators can verify the systems are operating. There are sensors/alarms for high level, pressure in the dissolved oxygen tank, UV light, and no effluent. There are no monitoring equipment (e.g., turbidity meters, etc.) or other mechanisms to verify effluent quality. The system can withstand a week without flow, and requires less than 1 hour to restart the system. Hamann also stated the systems are modular and have been retrofit on vessels.

Hamann does a retest of the system approximately 6 months after the unit has been installed on a vessel to verify its operating properly. After that, periodic effluent testing is based on the any voluntary sampling done by the ships crew. Hamann did the initial IMO certification in a laboratory in Germany for their system, and Rudy stated that test data for certification was considered CBI and is therefore not available to ERG and EPA.

1[1] USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.
2[2] IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, 0.5 mg/L TRC, and pH 6 to 8.5.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Headworks Bio, Inc.

Contact: Graham Dempster
Location: Victoria, BC
Phone: 250-381-8850

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on traditional Type II MSDs and Advanced Wastewater Treatment Systems (AWTS) for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to Headworks Bio.

Overview:

Headworks Bio acquired the assets of Hydroxyl Services, Inc. in bankruptcy proceedings in 2009. Headworks Bio manufactures and sells the CleanSea advanced wastewater treatment system (AWTS) that has been type certified by both U.S. Coast Guard (USCG)[1] and IMO Resolution MEPC 159(55)[2]. The CleanSea system is also approved for continuous discharge in Alaska by ADEC. Systems are designed for large cruise ships with at least 1,000 passengers (500 to 3,000 m^3/day flow). The system is installed on the largest cruise ship in the world - Royal Caribbean's Oasis of the Seas with 8,000 persons on board. The system is currently operating on 10 large cruise ships: 7 Royal Caribbean cruise ships and 3 Celebrity cruise ships. The system is a moving bed biological reactor (MBBR) and is designed for the removal BOD, COD, TSS, fecal coliform bacteria, and ammonia nitrogen. The CleanSea system can treat all types of blackwater and graywater, including food pulper filtrate (i.e. food pulper wastewater that has been screened). Systems can treat blackwater only or commingled blackwater and graywater; however, no one is only treating graywater with a CleanSea system according to Graham. For example, on the Oasis of the Seas, 7% to 10% of flow to the treatment system is from blackwater, 50% is from hotel operations (sinks, showers, etc.), 15% from laundry, and the remaining volume (20% to 30%) are from other sources according to Mr. Dempster. Headworks Bio has retrofit the CleanSea system on 7 large cruise ships to date. Mr. Dempster stated that since the systems are very large, they can only be retrofit onto vessels having existing advanced wastewater treatment systems; they can not be retrofit into spaces originally designed for traditional Type II MSDs that performed only maceration and chlorination.

Treatment begins with initial solids removal using screens and dissolved air flotation (DAF). Effluent from the DAF enters the MBBR system, which is an aerobic process containing thousands of polyethylene biofilm carriers suspended in mixed motion in the aeration tank. The polyethylene carriers provide a surface for the heterotrophic and autotrophic bacteria to attach. Effluent from the aerated MBBR tanks flows into dissolved air flotation tanks for solids removal, followed by optional mixed media filters to remove fine solids. After final filtration, the effluent is disinfected using UV lamps. The system is designed for nitrification to meet Alaska Water Quality Standards for ammonia. To date, Headworks has not installed denitrification on a vessel, but they are currently looking into the issue due to the new Baltic States requirements for total nitrogen removal.

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[1] USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.
[2] IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, pH 6 to 8.5.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Owens Manufacturing and Specialty Co.

Contact: Stephen (New Owner)
Phone: 800-639-2744

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI, however we are not able to receive CBI information at this time, and that data that is not claimed as CBI can be used publicly without notice to Owens Manufacturing.

Overview:

Owens Manufacturing and Specialty Company manufactures U.S. Coast Guard (USCG)[1] and IMO Resolution MEPC 159(55)[2] approved Type II MSDs. Systems can be installed on vessels having between 3 and 350 passengers when treating only sewage, and between 1 and 120 passengers when treating commingled sewage and graywater. Owens Type II MSDs have been installed primarily on tug boats, lift boats, drilling vessels, tow boats and very few ferries, but not cruise ships. The system is capable of treating only sewage, or commingled graywater/sewage at a ratio of 2 to 1 by volume. The system is not capable of treating only graywater. Graywater sources include showers, sinks, galley and some ground food waste. Grease should be removed from graywater sources before entering the system. The system treats bacteria, TSS, and BOD. It is not designed to treat ammonia or phosphorous.

Owens's systems are biological. Sewage enters into a catch basin where large non-biodegrabable items are filtered out. Sewage then enters an aeration chamber where air is forced through a diffuser. Bacteria present in the aeration chamber digest solids and organic matter. Wastewater is then transferred to a solids settling chamber, where the heavier solids settle. These are directed back to the aeration chamber for further treatment. Floating solids are also captured using floating airlift skimmers, and are transferred back to the aeration chamber for further treatment. Wastewater is transferred over baffles and weirs into a chlorine contact chamber (tablet calcium hypochlorite) for 30 minutes. Treated effluent passes through a carbon bed to remove residual chlorine before discharge overboard. Sludge generated onboard is not processed, but is held for either discharge at sea or discharge to a land-based treatment system.

According to Owens, the system requires little to no operator attention. Blowers on the system provide aeration on a 15 minute on-off cycle, and the blower system should remain operational, even when there is no flow to the system. Owens stated the system can withstand a period of approximately 4 days without flow. Owens also stated the systems have been retrofit on vessels, typically to replace existing MSDs.

Owens recently developed data for recertification of the Type II MSD to the IMO Resolution MEPC 159(55) standards; however, Stephen stated that test data for recertification was considered CBI and is therefore not available to ERG and EPA.

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1 USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.
2 IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, pH 6 to 8.5.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Red Fox Environmental Services, Inc.
Youngsville, LA

Contact: Brooks
Phone: 337 856 3709
Date: November 16, 2010

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI, however we are not able to receive CBI information at this time, and that data that is not claimed as CBI can be used publicly without notice to Red Fox Environmental Services.

Overview:

Red Fox Environmental Services manufactures U.S. Coast Guard (USCG)[1]and IMO Resolution MEPC 159(55)[2] approved Type II MSDs. Systems can be installed on vessels having between 3 and 1,250 passengers when treating only sewage, and between 1 and 500 passengers when treating commingled sewage and graywater. Red Fox Type II MSDs have been installed primarily on tug boats, drilling vessels, tow boats and ferries and pleasure yachts, but not cruise ships. The system has been installed on about 5,200 vessels. The system is capable of treating only sewage, or commingled graywater/sewage at a ratio of 2 to 1 by volume, but works best with commingled wastewater. The system is not capable of treating only graywater. Graywater sources include showers, sinks, galley and some ground food waste. According to Brooks, if the material in the graywater is biodegradable, it can be discharged to the Type II MSD, including ground food waste. Grease should be removed from graywater sources before entering the system. The system treats bacteria, TSS, and BOD. It is not designed to treat ammonia or phosphorous.

Red Fox's systems are biological and include a four step process which includes coarse screening, aeration, clarification and settling, and disinfection. As the influent enters the sewage treatment unit, it passes through a bar strainer. This strainer will catch any large trash such as rags, plastic bags, etc., and prevent it from entering the system. Aeration supports the naturally occurring bacteria that eliminates the waste, and clarification and settling causes the separation of the bacteria sludge from the treated water. The clarifier operates under a fluid head pressure allowing flocculation and settling of the solids in the clarification chamber to occur even when the vessel is in motion. Final disinfection is accomplished with chlorine tables, although a chlorine generator can be retrofit to the system. He stated at they have tried to operate the system with a UV unit instead of using chlorine tablets, but UV maintenance is too costly.

According to Owens, the system requires little to no operator attention. According to Brooks, an operator should inspect the system daily to ensure all systems are operating. Blowers on the system should operate continuously to provide aeration to the bacteria. Red Fox stated the system can withstand a period of approximately 2 to 3 weeks without flow. Red Fox also stated the systems have been retrofit on vessels.

Red Fox recently developed data for recertification of the Type II MSD to the IMO Resolution MEPC 159(55) standards. Brooks stated the data may be available, but ERG would need to send an email requesting the information.

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1 USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.
2 IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, 0.5 mg/L TRC, and pH 6 to 8.5.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Rochem
Fort Lauderdale, Florida

Contact: Eric Neuman
Phone: 954 523 6299
Date: December 6, 2010

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to Rochem.

Overview:

After explaining why ERG was contacting Rochem, Rochem explained they market two systems for vessel blackwater and graywater treatment: a low-pressure reverse osmosis system and a membrane bioreactor (MBR). The MBR is used on all sizes of vessels, from large cruise ships to vessels as small as mega-yachts. The MBR system is currently IMO MEPC 159(55) certified; both systems are US Coast Guard certified. According to Eric, Rochem systems can handle all types of graywater except dewatered food pulper. Rochem systems were originally designed for blackwater treatment and do not require graywater for operation. Rochem MBR systems do require blackwater for proper operation. Systems can treat galley wastewater with some oil and grease, but do not perform well with high levels of grease or cooking oils.

Rochem systems have been retrofit on to a number of the Seaborn medium-size cruise ships operated by Carnival Cruise Lines. According to Mr. Neuman, the Rochem systems have a smaller footprint than biological Type II MSDs and typically can be substituted for these systems. However, the system is much larger than maceration/chlorination systems like the Hamman systems installed on Royal Caribbean vessels; therefore, retrofit in these systems would not be possible. Rochem systems have been installed on a variety of non-US Naval vessels. Rochem systems have been certified on a number of vessels operating in Alaska.

Rochem systems do not require small vessels to hire a specific operator for the MBRs; although, the large cruise ships sometimes do hire an operator. Typically, operation of the system is performed by the vessel engineer who is operating other systems such as the vessel's HVAC system. Mr. Neuman stated the Rochem systems can go without feed for 24 hours, but extended periods can result in poor effluent quality. He stated that some cruise ships do performance sampling to verify the systems are operating appropriately, but Rochem does not generally do on-going performance sampling. Sampling is the responsibility of the vessel operator. He went on to state that a number of the type-certified MSDs installed on vessels are not discharging effluent that are in compliance with USCG standards, and EPA is now beginning to take a look at the effluent quality from these types of systems.

Mr. Neuman stated he would be interested in participating in EPA's vessel listening session scheduled for December 15, 2010 and Kathleen Wu would email him the information on how to participate in the conference call.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Type II MSD and AWTS Vendors
Scanship Americas, Inc.

Contact: Alex
Location: Davie, Florida
Phone: 954 651 6205

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on Type II MSDs and Advanced Wastewater Treatment Systems for graywater as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time, and that data that is not claimed as CBI can be used publicly without notice to Scanship.

Overview:
Scanship manufactures U.S. Coast Guard (USCG)[1] and IMO Resolution MEPC 159(55)[2] approved Type II MSDs. Scanship systems are also approved for discharge in Alaska. Systems can be installed on vessels having as few as 100 persons. Scanship is currently installing a system for Chevron on a ferry in Australia that is being used as a floating living platform for employees. It is the smallest vessel this system is installed on. The ferry will have between 300 and 400 persons on board. The system is located in "sensitive waters" and Scanship is providing the system for continuous discharge. All Scanship systems are aerobic biological treatment with dissolved air flotation for solids removal. Solids collected from the systems are centrifuged and packaged for on-board incineration. Scanship systems can treat all types of blackwater and graywater, including food pulper wastewater; however, food pulper wastewater can cause "hiccups" in the system. As a result, vessels are now centrifuging the food pulper wastewater to remove solids, and only the liquid fraction is being sent to the treatment system. Systems can operate treating blackwater only or commingled blackwater and graywater; however, no one is treating only graywater with a Scanship system. Alex stated that approximately 60 percent of the Scanship systems currently being sold are retrofits, and that all new systems have nitrification and denitrification. Systems are large and are typically not designed for vessels with small numbers of passengers such as cargo ships. He stated these ships typically hold wastewater and discharge in the open ocean.

To meet Alaska water quality standards for ammonia nitrogen, Scanship has recently installed a nitrification-denitrification system on the Norwegian Star. The nitrification-denitrification system includes a pure oxygen system to increase aeration capacity and a final non-aerated anoxic denitrification tank. Alex stated there is a recycle loop from the anoxic tank to the aeration tank to provide alkalinity and pH control for nitrification. He said that nitrification consumes alkalinity and denitrification generates alkalinity so a portion of the denitrification effluent is recycled to balance alkalinity. The Norwegian Star is currently sailing between Los Angeles and the Mexican Baja peninsula. On-board engineers are currently fine-tuning the nitrification-denitrification system for nitrogen removal so that when the vessel returns to Alaska in the spring, effluent will achieve the Alaska Water Quality Standard. Once the system has been fine-tuned, the nitrification/denitrification will be operated continuously regardless of the vessel's location since it can take up to 2 months to get the system up and running properly according to Alex. Alex stated the Scanship system can withstand a period of approximately 1 week without flow/feed. After

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1 USCG has the following limits: 150 mg/L TSS and 200 CFU/100 ml fecal coliforms.

2 IMO Resolution MEPC 159(55) has the following effluent limits: 25 mg/L BOD, 35 mg/L TSS, 125 mg/L COD, 100 CFU/100 ml fecal coliforms, pH 6 to 8.5.

a week, the vessel must start feeding sugar water to keep the system operating. Operator attention for the system is approximately 2-3 hours per day. Real-time data collection from the system includes TSS, UV light intensity for the disinfection system and pH. These parameters allow the operators to continuously monitor the system.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Small Passenger Vessels
AEP River Operations

Contact: Matt Lagarde
Location: St. Louis, MO
Phone: 225 562 5050

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on graywater management from small passenger vessels as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to AEP River Operations.

Overview:

AEP River Operations (AEP) operates 23 tug boats on the Mississippi River. Twenty-one of the 23 tugs have 6 man crews, and two tugs have 9 man crews. Each vessel has a Type II MSD manufactured by Owens KleenTank that provides biological treatment and chlorine tablet disinfection. All of the tugs used by AEP River operations were constructed in 2007. Graywater generated by the vessels include accommodations, galley and laundry. In anticipation of new discharge standards for graywater, AEP specified in the design of the 2007 tugs that all graywater be piped to the disinfection portion of the Type II MSD to remove bacteria prior to overboard discharge. According to Mr. Legarde, this is not common on most tug boats. Older tugs discharge graywater directly overboard with out treatment. In addition, there is typically no holding capacity (tankage) for graywater on board tug boats.

When asked about possible discharge to shore-side treatment facilities, Mr. Legarde stated that it’s not possible for tug boats. Tugs are fueled by other vessels that pull along side as the tug is managing barges in the middle of the river. If graywater was to be discharged to shore-side facilities, holding tanks would need to be installed on the tugs, and other vessels would need to pull along side tug when in operation to off-load graywater. Mr. Legarde stated that management of graywater in this fashion is not practical since most vessels such as those delivering fuel do not want to mix water into their tanks. There are currently no operators on the river system that are receiving graywater that is then taken to shore for disposal.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

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Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Small Passenger Vessels
American Cruise Lines

Contact: John Ayer
Location: Gulfport, CT
Phone: 203 453 6800

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on graywater management from small passenger vessels as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time., Data that is not claimed as CBI can be used publicly without notice to American Cruise Lines.

Overview:

American Cruise Lines operates 4 small cruise ships along the Atlantic coast of the United States, and one vessel in the Columbia River. Home ports include Bangor and Portland, Maine; Providence, Rhode Island; New York City; Baltimore, Maryland; and Charleston, South Carolina. American Cruise Lines also travel up the Hudson River to Troy, New York. The vessels are approximately 210' in length and carry 98 passengers and 25 crew members. Vessels traveling along the Atlantic coast are less than 3 nautical miles from shore approximately 60 percent of the time. Each vessel has a Type II MSD that provides maceration and chlorination of blackwater only. Mr. Ayer did not know the vendor for the Type II MSDs treating blackwater. In addition, Mr. Ayer did not have any information on the volume of blackwater or graywater generated by the American Cruise Line vessels.

Graywater generated by the vessels include accommodations, galley and laundry. Graywater is discharged directly overboard, except when the vessels are in No Discharge Zones (NDZs). In those instances, graywater is held in on-board holding tanks and is then either discharged when the vessel leaves the NDZ, when the vessel is outside 3 nautical miles, or to shore-side facilities. Treated blackwater is also held in holding tanks when the vessels are in NDZ and then discharged overboard when outside the NDZ, outside 3 nm, or to shore-side facilities. Mr. Ayer stated the vessels try to limit graywater generation through low-flow shower heads, and all soaps and detergents are biodegradable and do not contain phosphates.

Mr. Ayer was aware of the VGP and said each of his 5 cruise ships have permits. He commented that if EPA was considering making vessels treat graywater to specific standards like the USCG standards for blackwater, they should first consider installing more shore-side receiving stations. He said there is a station in Bangor, Maine that receives wastewater from holding tanks, and in Troy, New York wastewater is trucked off the dock for shore-side treatment. He indicated that large docks have some shoreside receiving stations and many of the small marinas have shore-side receiving stations for large yachts, but their 200' vessels are too large to hook up to these systems. He feels that it would be far more cost effective to install shore-side receiving stations than to force all vessels to install more advanced and larger MSDs to treat graywater.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Small Passenger Vessels
Anglo-Eastern Container Ships

Contact: Anuj Chopra
Location: Stanford, Texas
Phone: 281 265 4814
Date: January 4, 2011

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on graywater management from small passenger vessels as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to Anglo-Eastern.

Overview:
Anglo-Eastern operates 40 U.S. flagged large container ships. Vessel ports include the Gulf Coast, Mid-Atlantic Coast, Pacific Coast (California) and Northwest Coast. Container vessels generally have a crew of 22 to 23 persons, but crews can range between 19 and 27 persons depending on vessel size. According to Mr. Chopra, cargo ships generate both graywater and blackwater. Blackwater is routed to the Type II MSD, all of which are maceration and chlorination on the Anglo Eastern vessels. While in port or within 3 nautical miles of shore, graywater is held in the vessels' aft peak ballast tank and is then discharged directly overboard without treatment once the vessel is outside 3 nm. According to Mr. Chopra, Anglo-Eastern must ask for permission from the State jurisdiction to place untreated graywater in ballast tanks. Graywater on the vessels is generated from the galley, sinks, showers and laundry.

According to Mr. Chopra, the Anglo-Eastern container ships can be in port from 24 hours up to 7 days which poses a problem for graywater storage. According to Mr. Chopra, vessels use approximately 18 tons/day of potable water. Approximately 4 tons is used in the engine room, 3-4 tons is for sewage (blackwater) and the remaining 10 tons/day is for graywater generation. Between 3 and 4 m3/day of graywater is generated by the galley. Anglo-Eastern is very concerned with placing graywater in the after-peak ballast tank. The tank can not be easily cleaned and residual solids that remain in the tank from graywater could become septic and generate hydrogen sulfide. Crew that must periodically enter the tank for inspection typically monitor for oxygen levels only. Mr. Chopra is also concerned that upcoming numeric ballast water regulations may prevent him from placing treated sewage and graywater in ballast tanks. He stated their Type II MSDs are type certified and he is not sure if they are actually working to their type certification standards. He said that sampling is never required and because of this he may be placing treated effluent with very high TSS and fecal coliforms in his ballast tanks that may cause problems with future ballast numeric standards.

Mr. Chopra feels the solution to graywater and also treated sewage is the installation of shore-side receiving facilities. He stated that Ango-Eastern docked vessels 1,100 times at U.S. ports last year and not one port had sewage and graywater receiving facilities. At one location near Portland, Oregon last year one, one vessel needed to off-load graywater from a ballast tank to allow the vessel to move up river. The cost to truck 25 m3 of graywater was $26,000. According to Mr. Chopra, this has a significant impact on the profit for container vessels.

Mr. Chopra would like EPA to visit their vessels to see first-hand how they manage graywater, the difficulty in holding graywater for extended periods of time in ballast tanks, and the problems with trying to clean ballast tanks.

Graywater Discharges from Vessels
EP-C-09-020, Work Assignment 1-10, Subtask 2A

Telephone Questions for Identified Small Passenger Vessels
Horizon Lines

Contact: Wally Becker
Location: New Jersey
Phone: 908 936 1802

ERG initially identified themselves as contractors to USEPA and explained that EPA was revisiting available information on graywater management from small passenger vessels as part of the reissuing the Vessel General Permit (VGP). ERG also explained that any responses can be claimed as CBI; however, we are not able to receive CBI information at this time. Data that is not claimed as CBI can be used publicly without notice to Horizon Lines.

Overview:

Horizon Lines operates 26 U.S.-flagged large container ships. Vessel ports include New York City; Jacksonville, Florida; San Juan, Porto Rico; Guam; Hawaii; and Alaska. Container vessels generally have a crew of 26 persons. According to Mr. Becker, cargo ships generate both graywater and blackwater. Blackwater is routed to the Type II MSD, all of which are maceration and chlorination on the Horizon Line vessels. Graywater is discharged directly overboard without treatment. Tanks could be made available to hold graywater while the vessel is within 3 nautical miles; however, significant piping changes would be required. Graywater generated onboard the cargo ships include accommodations (sinks, showers), galley and laundry. All graywater from the galley passes through a grease trap to remove floating oils prior to discharge.

According to Mr. Becker, the Horizon Cargo ships are typically in port for 12 hours to unload and load containers before they head back to sea. Mr. Becker indicated that for some ports like New York Harbor, it can take up to 3 hours to dock and another 3 hours to go underway, so the total time the vessel is within 3 nm of shore could be up to 18 hours. Cargo ships that travel along the United States coast are typically 25 nm from shore. The shortest voyage for a Horizon Line cargo ship is 1 week, but most are 2 weeks. Travel from the west coast of the United States to Asia is a 35 day voyage.

While the vessels are in port, the primary graywater that is generated is galley wastewater, since the crew needs to be feed during the unloading/loading time. Graywater from accommodations and laundry is typically generated when the vessel is on route to the next port, which is outside the 3 nautical mile range. The Horizon line cargo ships try to limit graywater generation by using low-flow showers, faucets, and in the galley, since potable water is generated on the vessel using a distillation system. According to Mr. Becker, potable water generation on-board is expensive; therefore, limiting potable water use and subsequent graywater generation is a cost saving measure.