PRINCESS CRUISES

Source Reduction Evaluation (SRE)

August 19, 2008
Final

RESUBMITTAL OF SOURCE REDUCTION EVALUATION - SRE

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APPENDICES

Introduction

Pursuant to section 1.9.1 in Alaska Department of Environmental Conservation Large Commercial Passenger Vessel Wastewater Discharge Permit No. 2007DB0002, Princess Cruises is re-submitting this Source Reduction Evaluation (SRE) to better identify methods to reduce the presence of these parameters (ammonia, copper, nickel, and zinc) as much as possible in the discharges authorized by this permit. It is our intention to satisfy the recommendations contained in Denise Koch, ADEC communication dated July 28, 2008 by this submission of our revised SRE. It is anticipated that this plan will be updated and amended as further information is gathered in the process of completing this evaluation.

Summary

It is Princess Cruises' objective to apply its Source Reduction Evaluation to find possible solutions at reducing the effluent parameters in order to achieve acceptable results. Princess Cruises expects this can be achieved by efforts under our plan which will fall into the following action categories:

Category 1
Using pre-treatment products to condition the wastewater before it enters the existing advanced waste water treatment system so that existing advanced waste water treatment systems can operate at optimum efficiency. These products are performance enhancers.

Category 2
Investigate possible sources for copper, nickel and zinc in influent to provide possible source reduction. This investigation involves internal factors such as understanding ship piping construction and water production systems which could contribute to metals being received into the ships wastewater system. This requires testing streams within the ship.

Category 3
Evaluating onboard reduction sources such as chemicals used onboard for cleaning, source reduction of parameters into the waste water from external influents such as bunkered water from various ports and onboard tests.

Category 4
Research technical solutions which may include system modification, retrofitting and/or redesign with various available vendors in order to reduce the quantities of the four parameters in the effluent.

Category 5
Pursue and contract external consultants, if considered to be productive and appropriate to conduct feasibility studies.

Category 6
Develop a timescale to meet the effluent limits as far as possible.

Category 7
Provide updates to ADEC of test results and/or trials being conducted.

Actions under each of these categories are described in more detail further below. First we would like to provide details of our ships voyaging to Alaska in 2008-2009.

Vessel Specific Information for 2009 Alaska Season – Table I

#	NAME OF SHIP	YEAR BUILT	GROSS TONNAGE	VESSEL CLASS	# VOYAGES	EC FEE	OR FEE	TYPE OF AWWTS	NUMBER OF UNITS	POTABLE WATER SYSTEM TYPE	REQUESTING DISCHARGE UNDER INTERIM LIMITS
1	CORAL	2002	91,627	CORAL	18	$31,500	$141,840	HAMWORTHY - MBR	2 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
2	DIAMOND	2004	115,875	DIAMOND	18	$49,500	$192,816	HAMWORTHY - MBR	3 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
3	GOLDEN	2001	108,865	GRAND	19	$52,250	$197,448	HAMWORTHY - MBR	3 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
4	ISLAND	2003	91,627	CORAL	18	$31,500	$141,840	HAMWORTHY - MBR	2 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
5	PACIFIC	1999	30,277	PACIFIC	9	$6,750	$24,336	HAMWORTHY - MBR	2 MBRS - 150 m^3	2-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
6	SAPPHIRE	2004	115,875	DIAMOND	18	$49,500	$192,816	HAMWORTHY - MBR	3 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
7	SEA	1998	77,000	SUN	11	$19,250	$87,912	HAMWORTHY - MBR	2 MBRS - 320 m^3	2-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC
8	STAR	2002	108,977	GRAND	19	$52,250	$197,448	HAMWORTHY - MBR	3 MBRS - 320 m^3	3-FLASH LOW PRESURE MULTI-STAGE	AMMONIA, COPPER, NICKEL, ZINC

- Coral Princess, Diamond Princess, Golden Princess, Island Princess, Sapphire Princess and Star Princess sail in Alaska in 2008 and return in 2009.
- Dawn Princess, Sun Princess and Tahitian Princess which sail in Alaska in 2008 will not return in 2009.
- Pacific Princess and Sea Princess which did not sail in Alaska in 2008 will sail in 2009

The Hamworthy technology was state of the art and designed to meet the Murkowski discharge requirements which it did and continues in all respects. It was not designed to achieve or sustain reduction of metals and ammonia.

Category 1

As a result of our initial source reduction evaluations, Princess Cruises has determined that the wastewater influent into the existing wastewater treatment system should be evaluated more closely in order to try to meet the interim and 2010 limits. In order to better process the ship's wastewater more effectively and efficiently the influent may require pre-treatment since the MBR(s) were not originally designed to meet these new set limits.

Princess Cruises is testing the use of Hepburn Bio Care products in its pre-treatment of its wastewater. Hepburn Bio Care is a leading expert in sustainable organic waste treatment products. The Hepburn process is based on using non toxic, non caustic, non flammable, biodegradable and biological cleaning and waste treatment products, based mainly on Alkyl-Polyglucoside detergent, organic acids, naturally occurring group one (not genetically modified) non-pathogenic organisms to break down all effluent and organic food waste. The biodegradability meets and in certain cases exceeds the OECD (Organization for Economic Cooperation) requirement on biodegradability.

The Hepburn Bio Care products which Princess Cruises are testing use the surface area in the wastewater piping to create a vast bioreactor throughout the ship, thus effectively pre-treating all organic waste streams in situ, prior to further treatment in the ships AWWTS (Advanced Waste Water Treatment Systems) manufactured by Hamworthy and known as MBR's (Membrane Bio-Reactors). The Hepburn products are designed to continuously biodegrade the ships wastewater by reducing the BOD (Biological Oxygen Demand) and TSS (Total Suspended Solids).

Ammonia (NH_3)

The Hepburn Bio Care products reduce the loading on the MBR's and keep the black water piping free of ammonium magnesium phosphates (scale). In particular Princess Cruises is evaluating the use of Hepburn Bio-Ammo-1000 which is a liquid formulation of Nitrosomonas used to convert ammonia to nitrite, and Nitrobacter that convert the nitrite to nitrate. The product is designed to remove ammonia quickly and conveniently in the aerobic biological treatment process within the ships bioreactors. The negative aspect is this product has a shelf life of 2 -3 weeks and must be refrigerated. Hamworthy has also stated that the MBR(s) original configuration was not originally designed to achieve or sustain nitrification process.

The Hepburn Bio Care products also eliminate odors from the wastewater. These products are intended to enhance the overall wastewater treatment process so that the influent entering the MBR's is subjected to an initial processing.

The following Hepburn Bio Care products are being tested:

1) Hepburn Bio WC – dosed into ships toilets
    a. Bio WC Product Description and Application – please see **Appendix A**
    b. Bio WC Product Material Safety Data Sheet – please see **Appendix B**

2) Hepburn Bio ET – dosed into mixing tanks
    a. Bio ET Product Description & Application – please see **Appendix C**
    b. Bio ET Product Material Safety Data Sheet – please see **Appendix D**

3) Hepburn Nutrient – dosed into MBR(s)
    a. Nutrient Product Description & Application – please see **Appendix E**
    b. Nutrient Product Material Safety Data Sheet – please see **Appendix F**

4) Hepburn Foam Fighter – dosed into EVAC tanks
    a. Foam Fighter Product Description & Application – please see **Appendix G**
    b. Foam Fighter Product Material Safety Data Sheet – please see **Appendix H**

5) Hepburn Ammo 1000 – dosed into Aeration Chamber
    a. Ammo 1000 Product Description & Application – please see **Appendix I**
    b. Ammo 1000 Product Material Safety Data Sheet – please see **Appendix J**

Please find the Dosing Diagram illustrating where the above products are introduced into the ships wastewater system – please see **Appendix K**

Category 2

Princess Cruises is evaluating all of the piping used for its potable water distribution systems. The main potable water system piping identified confirms that the material is made from stainless steel AISA and does not contain any of the parameter metals in the permit. Copper pipe is used in some smaller areas of the ship such as for cold and hot potable water pipes fitted on prefabricated bath rooms. Further analysis will be necessary to determine if piping material is leaching into wastewater systems. Additionally the water generators (evaporators) will also have to be evaluated for the types of metals used within the systems including hot water heat exchangers. For technical data identifying piping system materials used – please see **Appendix L**

In order to better understand the influent going through the ships wastewater treatment systems a study was recently commissioned by Princess Cruises in order to test the internal metals contained within the potable water distribution system of the ship. Admiralty Environmental was contracted to perform a third party sampling and testing evaluation assessment. Samples were taken from a variety of points onboard the Star Princess. These samples were analyzed in the same manner as compliance samples are analyzed. Please find the table below providing the results from our test. The results that are above the 2010 ADEC general permit regulatory limits are in bold.

Onboard Potable Water Distribution System Testing Results – Table II

Sampling Location – Star Princess	Sample Date	Dissolved Copper (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)
Potable Water Tank (8&9) after Retention	06/17/08	**15.3**	1.74	17.8
Tap Water – Bridge Pantry Deck 14	06/17/08	**19.5**	1.87	26.9
Crew Cabin Deck 10 Fwd. Port (Hot Water)	06/17/08	**52.3**	**8.27**	33.5
Pax. Cabin Deck 8 Fwd. Stbd. (Hot Water)	06/17/08	**56.3**	**8.2**	34.9
Pax. Cabin Deck 11 Port Midship	06/17/08	**44.7**	2.21	33.7
Crew Cabin Deck 4 Port	06/17/08	**41.6**	1.85	40
Tap Water – Crew Galley Deck 5 Aft (Hot)	06/17/08	**26.3**	**10.4**	25.2
Designated Overboard Discharge Sample Port	06/18/08	**59.2**	**13.6**	**123**
Alternate Overboard Discharge Sample Point	06/18/08	**116**	**258**	**183**
Influent MBR – Blackwater - Evac. 4	06/18/08	**17**	**8.58**	**115**
Influent MBR – Graywater – Buffer Tank	06/18/08	**22.5**	7.64	**94.6**
Potable Water Tank (11-12) after Retention	06/18/08	**17.6**	1.48	18
Evaporator 1	06/20/08	**49.7**	3.13	15.4
Evaporator 3	06/20/08	**42.5**	1.04	51.8
Evaporator 2	06/23/08	**50.3**	1	28.1
Designated Overboard Discharge Sample Port	06/25/08	**55.5**	**15.7**	**119**

In general, levels of dissolved copper, nickel, and zinc observed in the final overboard permeate of the Star Princess are for the most part a result of high levels of dissolved metals taken on board from bunker water connections and also partially generated by sources within the ship.

For the complete report of the final lab results which includes the analytical results, case narratives, and chains of custody – please see **Appendix M**

In order to better understand the ships water systems and evaporator systems we are utilizing the following detailed descriptions and illustrations – please see **Appendix N**

Category 3

The purpose of this category will be to identify potential sources of copper, zinc, nickel and ammonia as they may enter the waste water stream, and to investigate and implement means to reduce their presence in the influent to the Advanced Waste Water Treatment Systems (AWWTS) on board. The major phases of this evaluation will be:

1. Document influent to waste streams as potential sources:
    a. Source water evaluation – such as bunkered potable water
    b. Other potential contributors – such as chemicals used

In order to better understand the influent going into the ships wastewater treatment systems another study was recently commissioned by Princess Cruises in order to test the ports where its ships routinely bunker potable water. Admiralty Environmental was contracted to perform a third party sampling and testing evaluation assessment.

Samples of water from bunker connections utilized by Princess ships were taken in the ports of Juneau, Ketchikan, San Francisco, Seattle, Skagway, Vancouver, Victoria, and Whittier for the analysis of dissolved copper, dissolved nickel, and dissolved zinc. A synopsis of the analytical results is listed below. Results that are above the 2010 ADEC general permit regulatory limits are in bold.

Shore Potable Water Testing Results – Table III

Sampling Location – Bunkered Water	Sample Date	Dissolved Copper (µg/L)	Dissolved Nickel (µg/L)	Dissolved Zinc (µg/L)
Skagway Bunkered Water – St. Forward Port	06/12/08	0.688	1.48	6.53
Ketchikan Bunkering Connection	06/17/08	**3.62**	0.212	4.14
Ketchikan Bunkered Water – St. Forward Port	06/17/08	0.43	0.2	6.49
Juneau Bunkering Connection (AJ Dock)	06/18/08	**28.1**	1.24	13.7
Victoria Bunkering Connection – On Pier	06/21/08	2.47	0.431	8.92
Seattle Bunkering Connection – Forward Port	06/22/08	0.749	0.39	5.85
Juneau Bunkering Conn. (S. Franklin Dock)	06/25/08	**41.7**	2.35	16
Seattle Princess Dock – North Berth	06/30/08	**34**	1.3	**2600**
San Francisco Bunkering Connection	7/16/08	0.83	<0.5	<5
Whittier Bunkering Connection	7/24/08	1.3	0.345	17.5
Vancouver Bunkering Connection North	7/24/08	1.5	<0.2	9.0
Vancouver Bunkering Connection Central	7/24/08	**15**	<0.2	**280**
Vancouver Bunkering Connection South	7/24/08	**7.8**	<0.2	6.0

Based on this set of samples, water from Juneau and Seattle bunker connections utilized by Princess Cruises' ships appears to contain elevated levels of dissolved copper relative to the other ports sampled, while Seattle Princess dock bunker water contains elevated zinc. The very high amount of dissolved zinc found in water taken from the North Berth of the Seattle dock may have been a result of sampling of stagnant water or contamination. However, dissolved zinc content in water from that bunker connection has been confirmed during a subsequent sampling event to be relatively high (700 µg/L).

EPA has classified zinc as a parameter under the National Secondary Drinking Water Regulations. National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. As such we are constrained to the zinc levels present in the various ports which are necessary for bunkering potable water. This information has caused us to focus more on copper, nickel and ammonia.

In accordance with the Alaska General Permit, a sample of Golden Princess' overboard permeate discharge was taken on 21 July 2008. The sample results were received on 8 August 2008 and indicated an exceedence of zinc with a result of 269 ug/L. In this particular case the potable water bunkered in Seattle most likely had contributed to this high value. A comprehensive review was made to determine if bunkering water in Seattle could be avoided. An internal assessment confirmed that it is critical for our ships to continue to bunker water in this port due to many operational safety constraints such as ships stability, maintaining critical reserve of fresh water onboard and additional fuel and energy usage otherwise required to produce potable water using the ships potable water generators (evaporators).

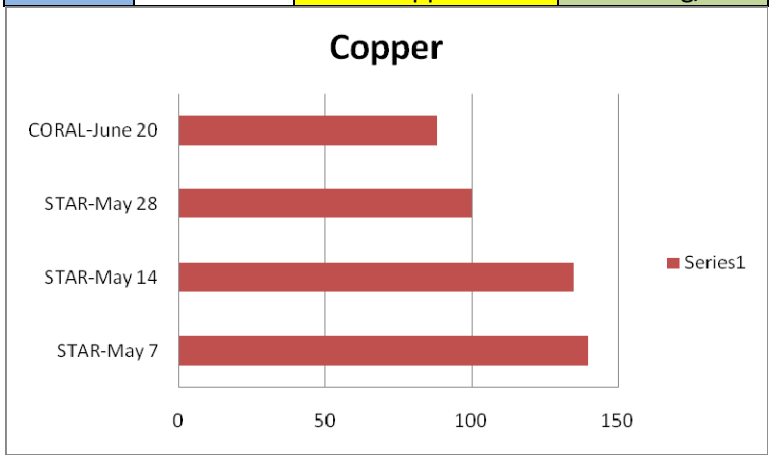
Princess Cruises is using this data to compare where its ships have had exceedences and if the bunkered water may have influenced sampling results.

Potable Water Bunker Ports – Table IV

#	PORTS	DIAMOND	SAPPHIRE	CORAL	ISLAND	DAWN	SUN	GOLDEN	STAR
1	JUNEAU	X	X	X	X	X	X		X
2	SKAGWAY	X	X	X	X	X		X	X
3	WHITTIER	X	X	X	X				
4	KETCHIKAN		X	X	X	X	X	X	X
5	KODIAK						X		
6	VANCOUVER	X	X	X					
7	VICTORIA					X	X	X	X
8	SEATTLE							X	X
9	SAN FRANCISCO					X	X		

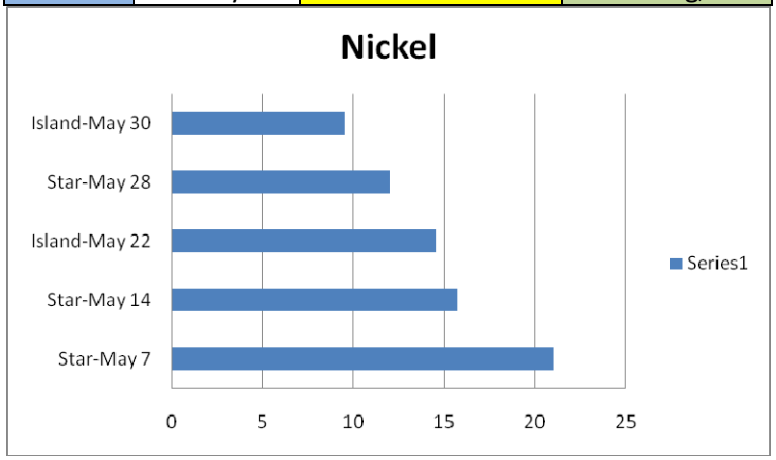
Copper Exceedences – Table V

SHIP	SAMPLE DATE	EXCEEDENCE PARAMETER	SHIP EXCEEDENCE RESULT
STAR	7-May-08	copper	140 ug/L
STAR	14-May-08	copper	135 ug/L
STAR	28-May-08	copper	100 ug/L
CORAL	20-Jun-08	copper	88.1 ug/L



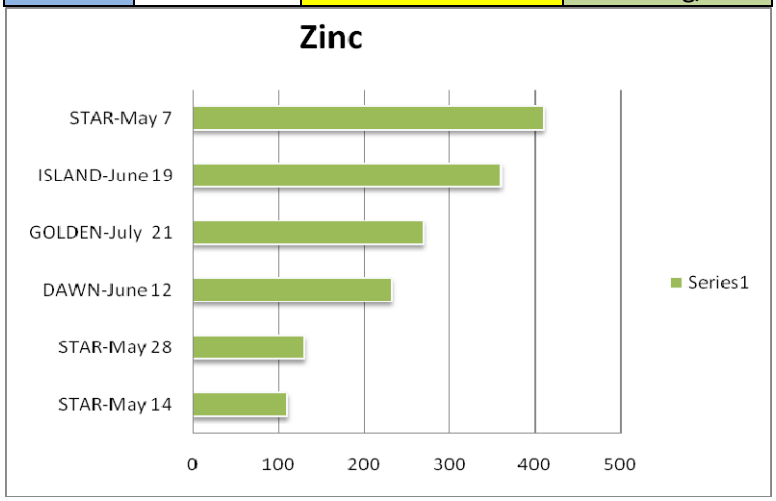
Nickel Exceedences – Table VI

SHIP	SAMPLE DATE	EXCEEDENCE PARAMETER	SHIP EXCEEDENCE RESULT
STAR	7-May-08	nickel	21 ug/L
STAR	14-May-08	nickel	15.7 ug/L
ISLAND	22-May-08	nickel	14.5 ug/L
STAR	28-May-08	nickel	12 ug/L
ISLAND	30-May-08	nickel	9.51 ug/L



Zinc Exceedences – Table VII

SHIP	SAMPLE DATE	EXCEEDENCE PARAMETER	SHIP EXCEEDENCE RESULT
STAR	7-May-08	zinc	410 ug/L
STAR	14-May-08	zinc	110 ug/L
STAR	28-May-08	zinc	130 ug/L
DAWN	12-Jun-08	zinc	232 ug/L
ISLAND	19-Jun-08	zinc	360 ug/L
GOLDEN	21-Jul-08	zinc	269 ug/L



Princess Cruises is also seeking additional results from ACA (Alaska Cruise Association) which are currently conducting another bunker water sampling program that includes the ports from San Francisco to Seward and every watering point on each dock. The contract is also through Dave Wetzel at Admiralty Environmental; they are testing for copper, zinc and nickel.

The goal is to test each water point each week and to capture at least 5 to 9 samples per site; whenever possible they test during the bunkering of water by a cruise ship. We currently have 1 week of preliminary testing data back from July 16th to July 21st. It will take at least three samples to start to get some patterns.

In order to better comprehend the potential introduction of ammonia, copper, nickel and zinc from certain products used for cleaning, our major suppliers will be contacted to assist us at pinpointing potential sources of origin.

Category 4

Treatment Technology Evaluation

Identification of potential treatment technologies for addressing the target parameters is complex and will considerably be dependent on new information, such as the influent source reduction evaluations described above. Therefore during the next 24 months Princess Cruises will work with Hamworthy and other vendors as necessary to evaluate additional treatment technologies as may be appropriate for reduction of these pollutants. We will update this plan and report on our technology evaluation progress by our developing timescale.

It should be noted that, to our knowledge, technology solutions are not yet commercially available for application on a large cruise ship, and therefore at present there still remains much uncertainty in the evaluation and potential implementation of such technologies. Princess Cruises is specifically working closely with Hamworthy, its supplier of Advanced Waste Water Treatment Systems (AWWTS). Princess Cruises has met and discussed with Hamworthy the necessity of achieving the 2010 effluent limits. On July 22, 2008 Princess Cruises was provided with a presentation by Dr. Wei Chen, Head of R&D at Hamworthy. Princess Cruises requested that Hamworthy provide information addressing actions which could be taken to see if current MBR(s) would be capable of achieving the new limits for ammonia, copper, nickel and zinc. For Hamworthy Presentation – please see Appendix O. In addition Princess Cruises has requested to meet with SCAN ships to discuss their reported emerging technology.

Background

Since the beginning of the 2008 Alaska season, Princess Cruises has identified a number of issues related to pH, Ammonia and metals. Efforts have been made by various parties to address these issues. These issues and efforts include:

- Low pH – adjustments to be made, i.e. reduce aeration
- Increased Ammonia – ongoing trial using Hepburn Bio Care Products
- Increased Metals – discuss with potential solutions with experts – no technical solution yet identified.
- Hamworthy proposal for a trial after 2008 Alaska season to test removal of ammonia;

Ammonia (NH_3)

The Cruise Ship Survey Report issued by USEPA in 2006 (USEPA Survey) demonstrated that the Hamworthy MBR were able to remove 70% of ammonia from the influent of combined black and accommodation grey water. Hamworthy states that this removal is primarily due to nutrient uptake by bacteria during the treatment process. For the systems that received less than designed loading rate, additional Ammonia reduction was achieved via a partial biological nitrification process. However, because the current MBR is designed for carbonaceous BOD removal only, the ammonia level in the treated water can be influenced by the ammonia level in the black and grey water, and its fluctuations.

While Hamworthy expect the ammonia level in the treated waste water to contain less than 80.4 mg/l, Hamworthy states they cannot guarantee to meet this limit at all times with current systems.

Considering that the majority of ammonia comes from black water, Hamworthy expects a MBR receiving more grey water to have a lower risk of non-compliance due to the dilution effect of grey water. However, unlike some of the other currently available systems, Hamworthy MBR's only treat accommodations greywater and do not treat other greywater streams. This fact accounts for more concentration of black water resulting in higher ammonia levels.

Technical background of existing Princess Cruises MBR(s)

Hamworthy's MBR systems were designed to remove BOD (carbon compounds) – by a group of bacteria which grow and reproduce quickly. This bacteria breathes in O2, consumes BOD as food, and produces CO2. At the same time it consumes small amounts of ammonia as nutrient.

Another group of bacteria, called nitrifiers, grow and reproduce slowly. The nitrifiers also breathe in O2, a lot of it, consume ammonia as food, and produce nitrate (NO3). This process is called biological nitrification. Unlike BOD removal, nitrification process generates acidity that consumes alkalinity – results in a drop of pH.

Nitrifiers and BOD removal bacteria will compete. Because nitrifers grow slowly, a bioreactor that is de-sludged less often will help to retain more nitrifiers which would otherwise be flushed out from the reactor over a period of time. A bioreactor that receives more BOD will grow more BOD removal bacteria, and likewise, a reactor that receives more ammonia will grow more nitrifers – if they are "well-kept". Nitrifiers are more vulnerable to toxicity, temperature shock, and are very sensitive e.g. for a reactor containing <1 mg/l of oxygen, BOD bacteria are perfectly stable, while nitrifiers will start to struggle.

The MBR when operated as designed allows the fast growing BOD bacteria to dominate the reactor because of the abundant carbon food available. To maintain a stable MLSS (Mixed Liquor Suspended Solids), sludge must be removed from the system at a certain rate.

When the MBR receives a far lower BOD loading than designed, with higher oxygen in the reactor content this results in a lower desludge rate, (hence a longer 'sludge age') and nitrification may occur to a degree within the current MBR (MKI) configuration. This is called partial nitrification because the process is unintentional, uncontrolled, and unstable.

Some of the BOD removal bacteria can use Nitrate (NO3) instead of O2. These bacteria are call de-nitrifiers. The de-nitrifiers 'breathe' in nitrate, consume BOD, and produce nitrogen gas (N2) – a process called biological denitrification. Denitrification process is important because it produces alkalinity to neutralize the pH. It also reduces aeration demand by utilizing the product (NO3) of a nitrification process.

Action plans

Princess Cruises intends to continue to achieve compliance to the Murkowski limits. Princess Cruises intends to invest in further technical investigations that lead to viable and reliable compliant solutions with 2010 limits.

1. Action plans to the ships that experience low pH (<6.5)

Hamworthy has recommended the following actions for MBR plants that suffer from repeated low pH:

- Increase MBR capacity by increasing grey water feed (to 80% of the rated capacity);
- Increase de-sludge rate or frequency (see table 1);
- Notify Hamworthy so that they can follow up.

Hamworthy believes the low pH is contributed by partial nitrification. The actions above will are suggested to effectively reduce the uncontrolled nitrification reaction from taking place. The aeration reduction could be one of the effective means of inhibiting nitrification, however, Hamworthy is not in position to conclude its potential risks on 'under aeration', and hence its risks to BOD compliance.

2. Action plans to the ships that experience high ammonia (>80 mg/l)

For ships or MBR plants that suffer from repeated high ammonia, Hamworthy recommended the following:

- If possible increase greywater dilution factor.
- Increase desludge frequency as stipulated in table 1.
- Notify Hamworthy of such ship or MBR plant so that they can follow up.

3. Lab analysis

Princess Cruises has agreed to provide Hamworthy its compliance laboratory sampling results, including additional nitrate testing as well as ammonia. This is to gain further confirmation and understanding of the pH, ammonia associated compliance issues.

At this moment in time Hamworthy will not guarantee to Princess Cruises that current MBR(s) will meet this very challenging ammonia limit.

Princess Cruises with Hamworthy will continue to investigate all applicable and proven technologies. As far as other treatment technologies we have obtained preliminary assessments and evaluations on a number of technologies, including 1) resin ion-exchange, 2) zeolite ion-exchange, 3) reverse osmosis, 4) ammonia stripping, and 5) advanced oxidation as a possible ammonia and heavy metal removal. Unfortunately, to date, Hamworthy's preliminary review with independent bodies has suggested these technologies are unsuitable or un-practical for cruise ship applications.

Hamworthy believes that 1) heavy metal removal is best managed at source, and 2) ammonia removal is approached using Biological Nitrogen Removal (BNR) process. BNR is a well proven process for ammonia removal. Hamworthy has presented a two stage proposal to Princess Cruises for a preliminary evaluation and if feasible a sea trial to explore BNR to perform nitrification and de-nitrification processes. Princess Cruises is reviewing this proposal and the possibility of conducting such a two phase evaluation to be commenced no later than end of December 2008.

Princess Cruises realizes that the solution to meeting the parameters may not come from just one vendor alone. Princess Cruises will consider evaluating other companies and the ones used by other cruise lines which may be further advanced at providing a system which can consistently achieve parameter limits. Princess Cruises has invited SCAN Ship on August 19, 2008 to discuss their available system technology.

Princess Cruises has also had discussions with ACAV Bluewater Innovations, Co. This Company provides consultation on possible technologies available to treat wastewater for ammonia and possible metals. Several developmental systems have been described as potential options, however none of which have been tested or trialed to confirm they will meet the parameters limits in operation. Discussions with this company continue.

Heavy Metals (Cu, Ni, Zn)

Hamworthy's MBR systems were not originally designed to remove heavy metals and the manufacturers have given Princess Cruises no guarantee that the heavy metal concentrations may be improved except possibly by better chemicals used onboard, water sourcing, and awareness to the issue.

Princess Cruises' has reviewed three methods to possibly control metals:

1) Carbon filters (possibly shore based, under the control of the port authorities) to remove any heavy metals from the bunker water before it gets to the ship.

2) By controlling the langlier index to archive a reading of between -0.5 and +0.5 (balanced)we will be able to minimize the effect the water has on the piping systems as well as controlling the scale forming tendencies of the water.

3) An alternative to langier index control is the use of FDA approved polyphosphate corrosion inhibitors in the PW system

At this moment in time Hamworthy will not guarantee to us that these most stringent metal limits for copper, nickel and zinc can be achieved with current technology. Hamworthy initiated studies with UK Water Research Centre, who confirmed this viewpoint.

Princess Cruises with Hamworthy and other vendors will continue to investigate technologies to satisfy the regulatory requirements.

Category 5

In addition to the consultants referenced earlier in this SRE, Princess Cruises will also consider additional consultants, as appropriate, to conduct feasibility studies. Karen Westenfeld of BP in Alaska was contacted to inquire about local consultants. Currently we are evaluating the following consultants.

1. Montgomery Watson Harza
   1835 S. Bragaw Street, Suite 350
   Anchorage, Alaska 99508
   Phone: 907-248-8883
   Fax: 907-248-8884

2. HDR Consulting
   2525 C Street, Suite 305
   Anchorage, Alaska 99503
   Phone: 907-644-2000

Category 6

Princess Cruises intends to provide ADEC with any further tests or sampling results of independent studies it may conduct as described in this SRE. We hope that this new data will continue to provide better knowledge and an understanding to the challenges required to ultimately finding a resolution.

Category 7

Princess Cruises intends to keep track of its SRE progress by use of a developing timescale. We hope that this timescale will help us manage our efforts and also account for the time consumed in order to work on these actions.

TIMESCALE **Table VIII**

DATE INITIATED	CATEGORY #	ACTION CATEGORY DESCRIPTION	ADEC PROGRESS REPORT
Jul-08	1	Hepburn Bio Care Products - Performance Enhancers	Jan-08
Jun-08	2	Onboard Potable Water Distribution System Testing	Jan-08
Jun-08	3	Source Water Evaluation - Shore Potable Water Testing	Jan-08
Sep-08	3	Evaluation of Cleaning Products	Jan-08
Dec-08	4	Treatment Technology - Hamworthy Two Phase Evaluation	Jan-08
Sep-08	5	Consultant	Jan-08
8-Aug	6-7	Results & Progress Report	Jan-09

Information Sources:

Admiralty Environmental – Mr. David Wetzel
431 N.Franklin St., Suite 101, Juneau, AK 99801
(907) 463-4415 (office) (480) 247-4476 (fax)
dwetzel@admiraltyenv.com

Hepburn Bio Care UK Ltd. – Ms. Margaret Hepburn
Unit F1, 10th Avenue
Deeside Industrial Park, Deeside, CH5 2UA, UK
+44 (0) 1244 280 775 (office) +44 (0) 1244 280 776 (fax)
m.v.hepburn@hepburnbiocare.com

Hamworthy KSE Ltd. – Dr. Wei Chen
Marine & Offshore, Fleet Corner Poole
Dorset BH17 0JT Eng
+44 (0) 1202 662 680 (office) and 305-597-7520 (Florida Office)
wchen@hamworthy.com

ACAV Bluewater Innovations Co. – Mr. Dan Mastropierro and Mr. Joseph Macrina
407-477-4533 (office) 407-341-7134 (mobile) 888-831-2281
jmacrina@blueH2Oi.com