



EXHIBIT 4
GOLDEN PRINCESS
AMMONIA REMOVAL TRIAL PROPOSAL

APPENDIX B

MBR No.3 SYSTEM MODIFICATION

Revised Nov 2008



Hamworthy proposed an ammonia removal trial on board Golden Princess in order to evaluate the feasibility and the reliability of a biological nitrification and de-nitrification process, and its possible limitations for cruise ship applications. This survey aims to:

- 1) Identify one suitable MBR unit for implementing the ammonia removal trial.
- 2) Establish a suitable interface system for this MBR unit, including a black and grey mixing tank.

The survey was supported by Mr. L Mento (Chief Eng), A Salza (Staff Eng), C Parisi (2nd Eng), W Saavedra, and A Gomisong (1st Plumber). It is concluded from this survey that, MBR No.3 is used for the trial, with Tank No. 5 to be modified as the mixing tank. The key findings are as below:

No.	Issues and conclusions	Action
1.	<p>Biological nitrification and denitrification using MBR 3 – Outline</p> <p>The small 1st stage of a MKIII MBR will be converted to an Anoxic tank, where denitrification process occurs. The large 2nd stage bioreactor will continue to serve as an Aerobic tank for achieving nitrification process. Therefore the required modification is kept to minimum. MBR 3 is selected because it is close to Tank 5.</p> <p>To attenuate the fluctuation of ammonia concentration in black (with very high ammonia) and grey water (with little ammonia), they must be balanced within a mixing tank (Tank 5) prior to feeding into MBR.</p>	
2	MBR No.3 1 st stage reactor modifications (Figure 1, 2, 3, 6)	
2.1	1 st stage reactor will be divided into two zones – an anoxic zone and a swing zone by inserting a new baffle wall within the 1 st stage reactor. Aeration diffusers are to be removed from the anoxic zone. 4 No. diffusers will be retained in the swing zone within the 1 st stage.	HWS
2.2	A mixing pump withdraws content from the anoxic zone, and returns this zone to provide mixing while avoiding turbulence at surface.	HWS
2.3	Interface details of all flows, including inlet, ISF suction, 2 nd stage overflow are to be reviewed to minimise short-circuiting, and air entrapment.	HWS
2.4	The MBR No.3 feed control will be modified to call the new duty/assist feed pumps at the Mixing Tank (Tank No. 5).	HWS
2.5	A chemical dosing system is to be installed for phosphorus removal. The dosing will interlock with the new MBR feed pumps.	HWS
2.6	A dosing system will be provided for Ammo1000 solution from Hepburn. Hepburn to advise control functions.	Hepburn
2.7	A dosing system will be provided for alkaline solution.	HWS
2.8	Additional instrumentation, including on-line monitoring of ammonia and nitrate within the bioreactor will be provided.	HWS
3	ISF modifications	
	None required. During commissioning/trial period, the ISF feed flow will be turned down to 2-3 times of daily MBR capacity.	
4	2 nd stage bioreactor modifications	
4.1	Software modification is required to provide additional timing control for the blowers.	HWS

	Certain diffusers may be turned off to minimise air entrapment in 2 nd stage overflow to the 1 st stage.	
4.2	The risk of foaming is generally greater with biological nitrification and denitrification processes. A new spray pump will be provided to withdrawn content from the 2 nd stage, and return via a valved manifold to the head space within the 2 nd stage, to the swing zone, to the anoxic zone in the 1 st stage, and to the existing foam tank.	HWS
5	Membrane bank, CIP system, Screen Press None required.	
6	Permeate tank	
6.1	On-line instruments will be provided, including Ammonia and possibly Nitrate for ship to fit, set-up and commission.	HWS
7.	Tank 5 modifications (Figure 1,4,5)	
7.1	The original Contact Tank is to be removed for making space for the new blowers and feed pumps. The tank is to be made good.	HWS
7.2	The tank is fitted with DP sensor for level control similar to MBR 1 st stage.	HWS
7.3	The tank is fitted with aeration down pipe for mixing. The blower shall be duty/standby with timing control functions.	HWS
7.4	Duty/assist feed pumps will transfer mixed black and grey water from Tank 5 to MBR No. 3 when called.	HWS
7.5	The tank will possibly be fitted with on-line monitoring device including Ammonia.	HWS
8	Interfaces to Tank 5 (Figure 1, 5)	
8.1	A new actuated valve will be fitted to the existing black water line to Tank 5 controlled by its DP sensor.	HWS
8.2	The grey water feed line will be installed, connecting from the Sanitary grey water main (at frame 147), into Tank 5 tank top. The line will have actuated valve controlled by DP sensor.	HWS
8.3	A new MBR feed line will be installed linking the duty standby feed pumps to the existing MBR 3 grey water feed line, down stream of the existing MBR 3 grey water actuated valve and check valve assembly.	HWS
9	Control	
9.1	A new control panel is provided for Tank 5 equipment and instrument.	HWS
9.2	MBR No.3 control panel capacity is to be reviewed.	HWS
10	Analysis instrument	
10.1	A set of bench analysis kits will be provided for on-board testing of COD, ammonia, nitrate, nitrite, alkalinity and phosphorus, by the operators. Training to be provided by Hamworthy for ship to complete.	HWS
10.2	Ship to provide facility suitable for above bench analysis.	Ship

(Wei Chen, Nov 2008)