Logistics and considerations of installation and operation of AWTS

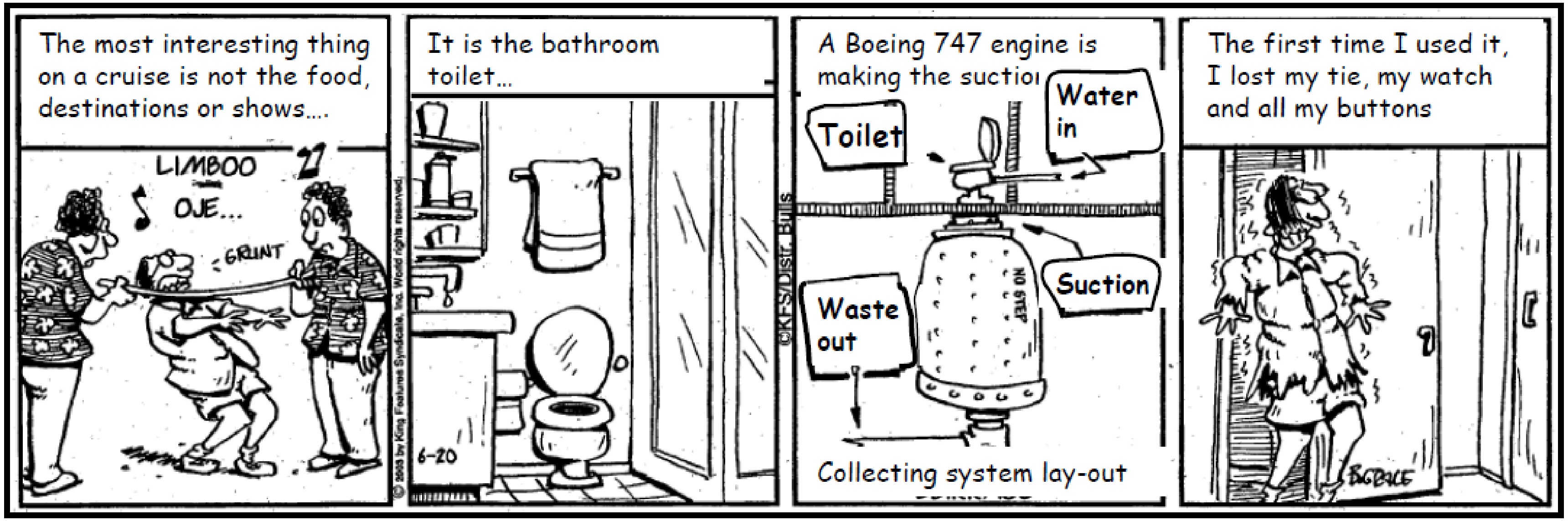
Alaska Cruise ship waste water science advisory panel

October 2010

Expected outcome and contents

- How to compare information to evaluate feasibility and make recommendations
- Contents:
  - Marine waste water treatment industry
    - Some History
    - Other Environmental rules affecting AWP's
  - Retrofit AWP project
    - Sizing the process + Cruise ship waste water sources & qualities
    - Process space reservation and components
    - Installation
    - Operation
  - New Alaska rules
    - How to move forward ?

Why do people take the Cruise ?



Some AWP history…Late 90's

- All ships were built to meet USCG and IMO Marpol Annex IV standards
  - Black water treated in biological or physical/chemical MSD's
  - Limited holding capacities and extended holding lead quickly to anoxic conditions
  - Grey water normally directly overboard
- Marine industry had no knowledge on what was going in and what was coming out of the MSD's
  - "No mechanical alarm" meant MSD was working properly

Years 2000 - 2005

- Cruise operators started quickly to adapt to new Alaska rules
  - Cruise operators selected a AWP supplier without any water treatment knowledge and AWP suppliers sold systems without ship waste knowledge
    - HAL => Zenon
    - NCL => Scanship
    - CCL => Rochem, Pall, Hamworthy
    - RCCL => Hydroxyl, Zenon
    - Disney => MEP
- Lots of operational issues
  - Sizing data was badly underestimated
  - Pumps and components not made for shipboard use
  - Crews were not educated to operate the systems and support was missing

2005-2010

- Companies (operators/suppliers) lost money:
  - delays on installations
  - operational issues had to be corrected
  - fierce competition on only few orders
    - Scanship, Hydroxyl, MEP, Navalis => Chapter 11
    - Pall, Zenon/GE, Rochem => out or not active anymore
- Operator knowledge improved and old AWP's are now in "acceptable condition"

  - Only few treating 100% all streams 24/7
- Various treatment experiences led to different internal policies among the Cruise lines

AWP situation today

- Cruise companies still dream on simple, small, no cost, on/off systems, but:
  - Have accepted that AWP's are what they are and that the systems need some "love and care"
  - Admit that the "wet side" is now under control to meet current Alaska standards
  - Issues mainly on:
    - Pre-screens, smell, sludge management & operational cost
    - Future rules and decisions what really to treat !

Other future environmental laws affecting the AWP

- Ballast water treatment
  - Capacity on Cruise ship 150-300m3/h
  - Seldomly used…Do we really need this?
  - 5-10m2 space, cost 250-350 TUSD/each +inst.
  - Currently shared treated waste water holding and Ballast tanks on older Cruise ships !!
- SECA SOx exhaust gas issues / MGO
  - Dual fuel need tankage space.
  - Is Scrubber allowed at ports and what to do with scrubber waste water streams and sludge?

IMO MEPC 61/7 Baltic sea

- Nutrient removal for sewage
  - The nutrient concentrations of the samples of effluent without dilution should be:
    - total nitrogen < 20 mg/*l or at least 70% reduction*
    - total phosphorus < 1.0 mg/*l or at least 80% reduction*
- Related to the proposed nutrient standards, it is proposed that the term "influent" should be defined as follows: "Influent means the total flow into the sewage treatment process". The reason for this addition is that, although influent containing grey water mixed with sewage is not considered dilution.
- The Government of each Party to the Convention undertakes to ensure that within a special area reception facilities in all relevant ports and terminals are provided for the reception of sewage.

Waste water treatment process

Wastewater treatment means removal of contaminants by various separation and oxidation processes to produce clean water

Design of a waste treatment process

1. Knowledge of influent / effluent parameters:

- Flow parameters and patterns => **Peak flow control!**
- Variation of concetrations => **Organic peak flow control!**
- Process risks, e.g. toxic substances
- Effluent limits

2. Hydraulic design of the process:

- Equalizing/holding/redundancy expectations
- Hydraulic Retention Time (HRT) of the process
- Design flux for membranes/DAF/UV etc. various process steps

Design of a waste treatment process

3. Organic design of the process:

- Prefiltration rate
- Mixed Liquor Suspended Solids (MLSS), Sludge Loading Rate (F/M),
- Sludge age etc. various sizing parameters according selected process

4. Supporting processes

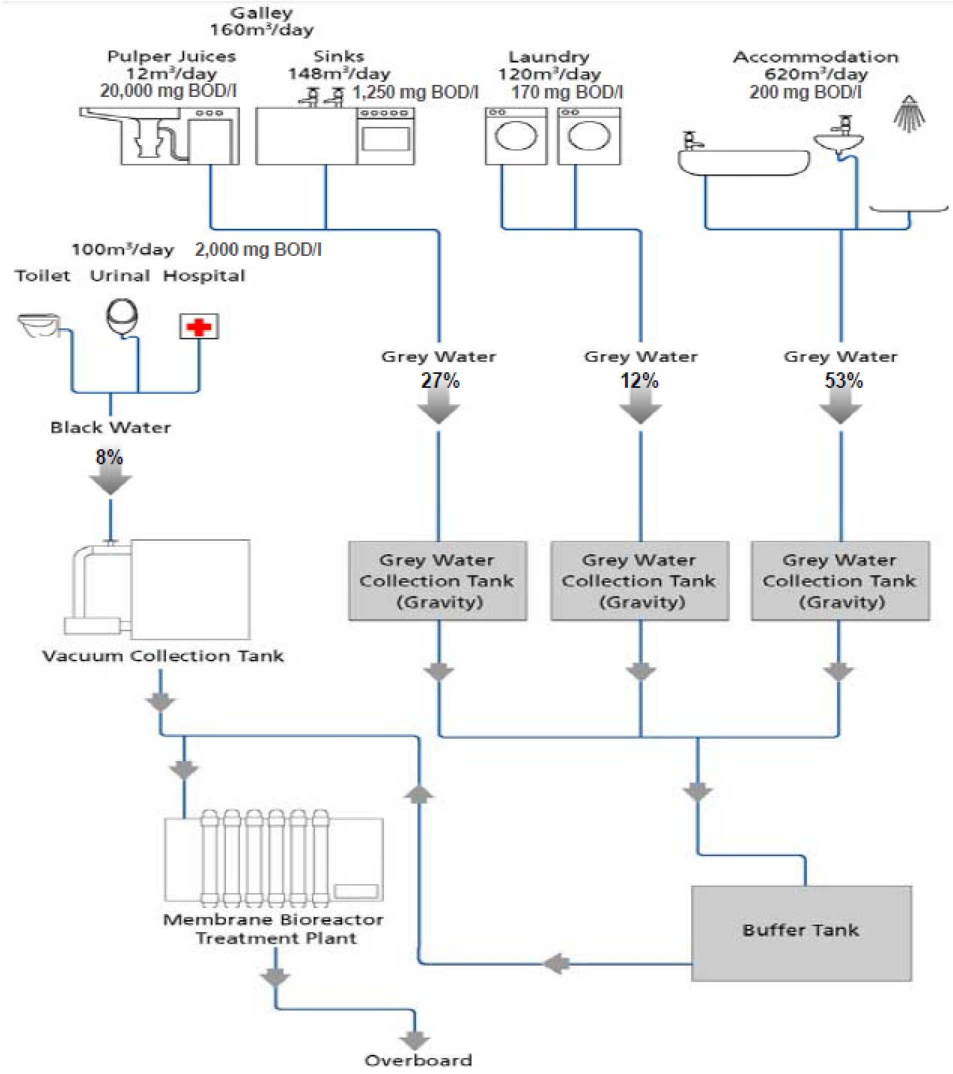
- Sludge management
  - Holding, dewatering, drying and/or incenerating
- Effluent holding and discharge
  - Discharge time and UV disinfection demand

Waste water soures

Questions raised on a retrofit project:

- How are the water streams collected?
- Transfer pump controls?
- Who controls the interfaces?
- Are the streams mixed or on separate tanks?

How much hydraulic and organic peaks are expected => How do we handle those in the AWP



Full sea day versus 10% empty 10 port day

Sewage treatment plant load calculator - Cruise ship (full sea day)

Number of crew	1000
Number of passangers	2300

Treated wastewater characteristics

	Y/N	l/p/d	gBOD/d	mg/l
Black water vacuum	1	20	45	2250
Black water gravity	0	70	45	0
Accommodation graywater	1	150	20	133
Galley water	1	50	125	2500
Laundry water	1	25	5	200
Pulper/foodwaste water	1	3	90	30000

Ship profile coefficient (α) calculator factors

No of Crew in cabins	1000	
No of Passangers in cabins	2300	
No of Public toilets&urinals	100	
Route hours/day, passangers	24	
Operational hours, crew	24	
Toilet flushes/person/day	7	
Hot meals served to passang	1	(1=YES, 0=NO)
Bed sheets washed onboard	1	(1=YES, 0=NO)

Corrected wastewater treatment loading

	Ship Profile	Hydraulic load	BOD5	COD	TSS	Concentrations BOD5	COD	TSS
	a	m3/day	kgO_2/day	kgO_2/day	kg/day	mg/l	mg/l	mg/l
Black water vacuum	***1,00***	66,0	148,5	297,0	104,0			
Black water gravity	***0,00***	0,0	0,0	0,0	0,0			
Accommodation graywater	***1,00***	495,0	66,0	125,4	39,6			
Galley water	***1,00***	165,0	412,5	618,8	247,5			
Laundry water	***1,00***	82,5	16,5	49,5	11,6			
Pulper/foodwaste water	***1,00***	9,9	297,0	445,5	207,9			
TOTAL		**818,40**	**940,50**	1536,15	610,50	1149	1877	746

Sewage treatment plant load calculator - Cruise ship (10% empty, 10 port day)

Number of crew	1000
Number of passangers	2000

Treated wastewater characteristics

	Y/N	l/p/d	gBOD/d	mg/l
Black water vacuum	1	20	45	2250
Black water gravity	0	70	45	0
Accommodation graywater	1	150	20	133
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Ship profile coefficient (α) calculator factors

No of Crew in cabins	1000	
No of Passangers in cabins	2000	
No of Public toilets&urinals	100	
Route hours/day, passangers	14	
Operational hours, crew	24	
Toilet flushes/person/day	6	
Hot meals served to passang	1	(1=YES, 0=NO)
Bed sheets washed onboard	1	(1=YES, 0=NO)

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Black water vacuum	***0,72***	43,3	97,5	195,0	68,3			
Black water gravity	***0,00***	0,0	0,0	0,0	0,0			
Accommodation graywater	***0,72***	325,0	43,3	82,3	26,0			
Galley water	***0,72***	108,3	270,8	406,3	162,5			
Laundry water	***1,00***	75,0	15,0	45,0	10,5			
Pulper/foodwaste water	***0,72***	6,5	195,0	292,5	136,5			
TOTAL		**558,17**	**621,67**	1021,08	403,75	1114	1829	723

32% reduced hydrayulic loading, 34% reduced organic loading

All streams or BW+AccGW

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Galley water	*0,00*	0,0	0,0	0,0	0,0			
Laundry water	*0,00*	0,0	0,0	0,0	0,0			
Pulper/foodwaste water	*0,00*	0,0	0,0	0,0	0,0			
TOTAL		**561.00**	**214.50**	422.40	143.55	382	753	256

32% reduced hydraulic loading, 77% reduced organic loading

Waste water sampling

- Sampling change from 9am (season 2008) to 3am (season 2009) by one operator:
  - Average ammonia on effluent 20-25% down
  - Despite huge mixing, BW production drop dramatically after 10pm partial cause for improved results
- Influent sampling even more challenging directly from the pipe
  - Multiple samples during whole day
  - Settling in tanks taken into consideration (freshnes, level and mixing)
  - Which waters are going in from where ?

AWP process design data

BLACKWATER								
Ship	**collecting**	**BOD**	**COD**	**SCOD**	**N**	**SS**	**litraa / henkilö**	**gBOD/pers/day**
TOTAL		95948	139466	15039	10209	97702	937	1954
Samples		47	24	7	20	47	47	47
Average		**2041**	**5811**	**2148**	**510**	**2079**	**20**	**42**
EPA measurement		*526*	*1140*			*545*	*65*	*34*
Cruise line spec		*2500*				*1500*	*17*	*43*

ACCOMMODATION GRAY								
Ship	**collecting**	**BOD**	**COD**	**SCOD**	**N**	**SS**	**litraa / henkilö**	**gBOD/pers/day**
TOTAL		10794	10898	1080	175	6371	586	133,848
Samples		45	25	6	12	45	6	6
Average		**240**	**436**	**180**	**15**	**142**	**98**	**22**
Cruise line Spec.		200				100	155	31

AWP process design data

GALLEY WATER

Ship	collecting	BOD	COD	SCOD	N	SS	litraa / henkilö	gBOD/pers/day
TOTAL		45617	66530	12585	885	30223		
Samples		20	20	6	14	22		
Average		**2281**	**3327**	**2098**	**63**	**1374**	**81**	**185**
Cruise line spec.		2500				2500	50	125

LAUNDRY WATER

Ship	collecting	BOD	COD	SCOD	N	SS	litraa / henkilö	gBOD/pers/day
TOTAL		6407	8570	1372	113	3415	278	22
Samples		42	22	5	12	43	6	6
Average		**153**	**390**	**274**	**9**	**79**	**46**	**4**
Cruise line spec.		300				300	25	8

PULPER WATER

Ship	collecting	BOD	COD	SCOD	N	SS	litraa / henkilö	gBOD/pers/day
TOTAL		980731	519500	29600	669	761512	0	0
Samples		28	7	3	3	27	10	10
Average		**35026**	**74214**	**9867**	**223**	**28204**	**3**	105
Cruise line spec.		30000				20000	3	90

Simple comparison of data

- Average untreated concentrations of Copper

Copper	total		dissolved
– 2004 average wastewater	677ug/l		167ug/l
– 2008 flow weighed av.total gray	510ug/l		195ug/l
– 2001 ADEC graywater	483ug/l		NA
– 2008 Laundry	278ug/l		253ug/l
– 2008 Galley	383ug/l		232ug/l
– 2008 Food pulper	208ug/l		15ug/l
Bunker source dissolved copper	Min.	Av.	Max.
– 2008 Admiralty Bunker	0,22	~10	280ug/l

Simple comparison of data

- Average untreated concentrations of Nickel

Nickel	total	dissolved
– 2004 average wastewater	34ug/l	17.2ug/l
– 2008 flow weighed av.total gray	29.7ug/l	18.2ug/l
– 2001 ADEC graywater	48.7ug/l	NA
– 2008 Laundry	6.19ug/l	4.85ug/l
– 2008 Galley	29.2ug/l	26.4ug/l
– 2008 Food pulper	22.4ug/l	31.1ug/l

Bunker source dissolved nickel	Min.	Av.	Max.
– 2008 Admiralty Bunker	0,1	~1.5	470ug/l

Simple comparison of data

- Average untreated concentrations of Zinc

	total		dissolved
– 2004 average wastewater	3130ug/l		792ug/l
– 2008 flow weighed av.total gray	2540ug/l		1610ug/l
– 2001 ADEC graywater	790ug/l		NA
– 2008 Laundry	345ug/l		266ug/l
– 2008 Galley	1460ug/l		1070ug/l
– 2008 Food pulper	6380ug/l		47800ug/l
Bunker source dissolved zinc	Min.	Av.	Max.
– 2008 Admiralty Bunker	1	~50	3300ug/l

Simple comparison of data

- Concentrations (2008 EPA totals, 25 samples)

	Copper	Nickel	Zinc
– Av.influent	519ug/l	22,4ug/l	986ug/l
– AWP biomass	10800ug/l	245ug/l	19400ug/l
– Screened solids	22700ug/l	537ug/l	33600ug/l
– Effluent	16,6ug/l	13,6ug/l	198ug/l
– Reduction	96-98%	0-48%	0-86%

Simple comparison of data

- Despite peak concentrations of bunker water on all three metals go beyond the average concentration met on the ships, the estimated average concentration shows that ships contrinute a lot more.
- The data collected by Alaska and EPA proove that current AWP’s remove a bulk of metals, but not all !!

Ammonia and metals on EPA 2008 report

In the future metals have to be specified also:

•Sources of pollution not totally known

•Suppliers do not know the reductions on their processes

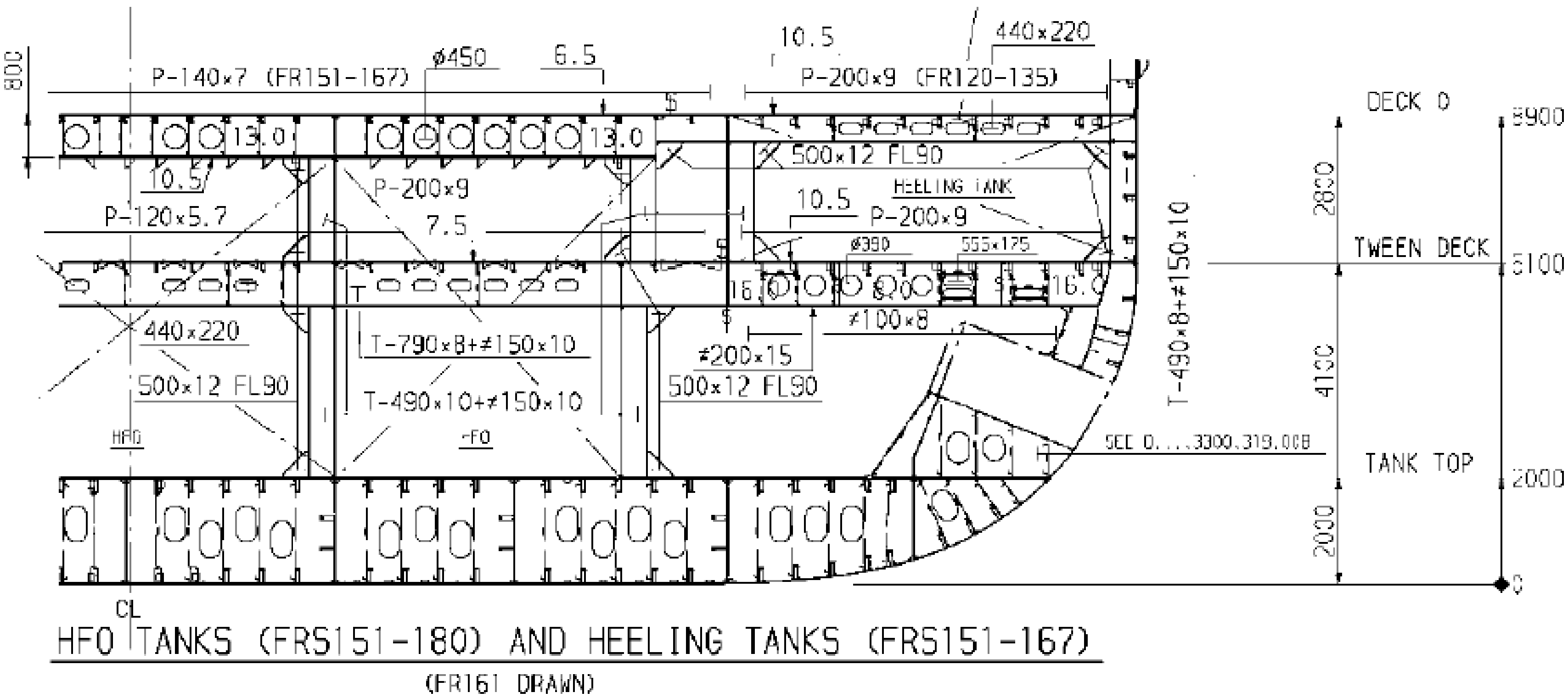
•All suppliers with units on operation are collecting data

HAL Veendam (Zenon)						COD	1130	50,4
		Limit	Laundry	Acc.	Pulper	Galley	AWP Infl.	AWP effl.
Ammonia	mg/l	2,9	0,36	1	29	0,46	56	7,58
Copper (TOT)	ug/l	3,1	258	975	400	88	246	8,97
Copper (dissolved)	ug/l		182	90	17,5	50,9	59	8
Nickel (TOT)	ug/l	8,2	10,7	29,4	41,6	25,8	27,3	15,3
Nickel (dissolved)	ug/l		7,3	19,6	38,6	22,8	22	15,5
Zinc (TOT)	ug/l	81	303	1500	4210	1010	947	360
Zinc (dissolved)	ug/l		178	635	3780	599	318	353
Norwegian Star (Scanship, no pulper)						COD	909	39,2
		Limit	Laundry	Acc.	Pulper	Galley	AWP Infl.	AWP effl.
Ammonia	mg/l	2,9					46	32
Copper (TOT)	ug/l	3,1	495	167	312	408	342	9,48
Copper (dissolved)	ug/l		553	89,1	23,9	61,8	113	6,51
Nickel (TOT)	ug/l	8,2	3,11	8,37	27,9	16,8	12,8	12,7
Nickel (dissolved)	ug/l		2,94	8,11	28,2	9,97	10,3	12,8
Zinc (TOT)	ug/l	81	455	323	987	500	349	673
Zinc (dissolved)	ug/l		464	218	634	324	99,9	656
Island Princess (Hamworthy, BW- AccGW treated)						COD	1930	114
		Limit	Laundry	Acc.	Pulper	Galley	AWP Infl.	AWP effl.
Ammonia	mg/l	2,9	1,29	0,43	35	11,1	221	33,6
Copper (TOT)	ug/l	3,1	325	580	118	620	1170	18,3
Copper (dissolved)	ug/l		242	462	4,4	479	44,7	16,9
Nickel (TOT)	ug/l	8,2	7,86	12,4	19,7	27	27,6	14,3
Nickel (dissolved)	ug/l		4,7	12,7	27	24,3	15,7	14
Zinc (TOT)	ug/l	81	470	604	20300	1090	1430	207
Zinc (dissolved)	ug/l		339	404	139000	956	100	205
Oosterdam (Rochem dual stream, no pulper)						COD	254	45
		Limit	Laundry	Acc.	Pulper	Galley	AWP gw/In	AWP gw/ef
Ammonia	mg/l	2,9					4,54	1,92
Copper (TOT)	ug/l	3,1	35,3	988	2,32	417	213	69,9
Copper (dissolved)	ug/l		35,6	26,3		335	109	18,3
Nickel (TOT)	ug/l	8,2	3,09	85,8	0,285	47,2	17,1	3,18
Nickel (dissolved)	ug/l		4,46	28,2		49,1	13,8	3,3
Zinc (TOT)	ug/l	81	151	10100	3,22	3260	791	383
Zinc (dissolved)	ug/l		82,4	1910		2390	170	279

Approx. AWP process size and cost

- Biological process 5000pax (1200m3/d)
  - Tank capacity 330m3
  - Foot print 80m2
  - Cost turnkey: 2 MUSD process + 1,5 MUSD installation
- Biological process 3000pax (800m3/d)
  - Tank capacity 240m3
  - Foot print 70m2 (lower tanks => worse oxygen transfer)
  - Cost turnkey: 1,5 MUSD process+ 1,2 MUSD installation
- Oxygen transfer to the process main limiting factor making reactor size larger

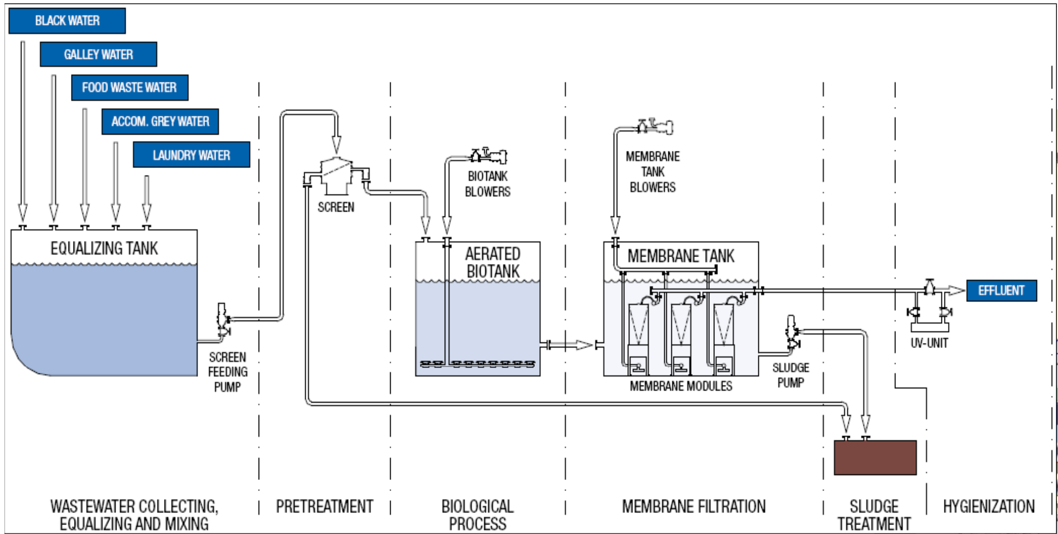
Normal deck heights

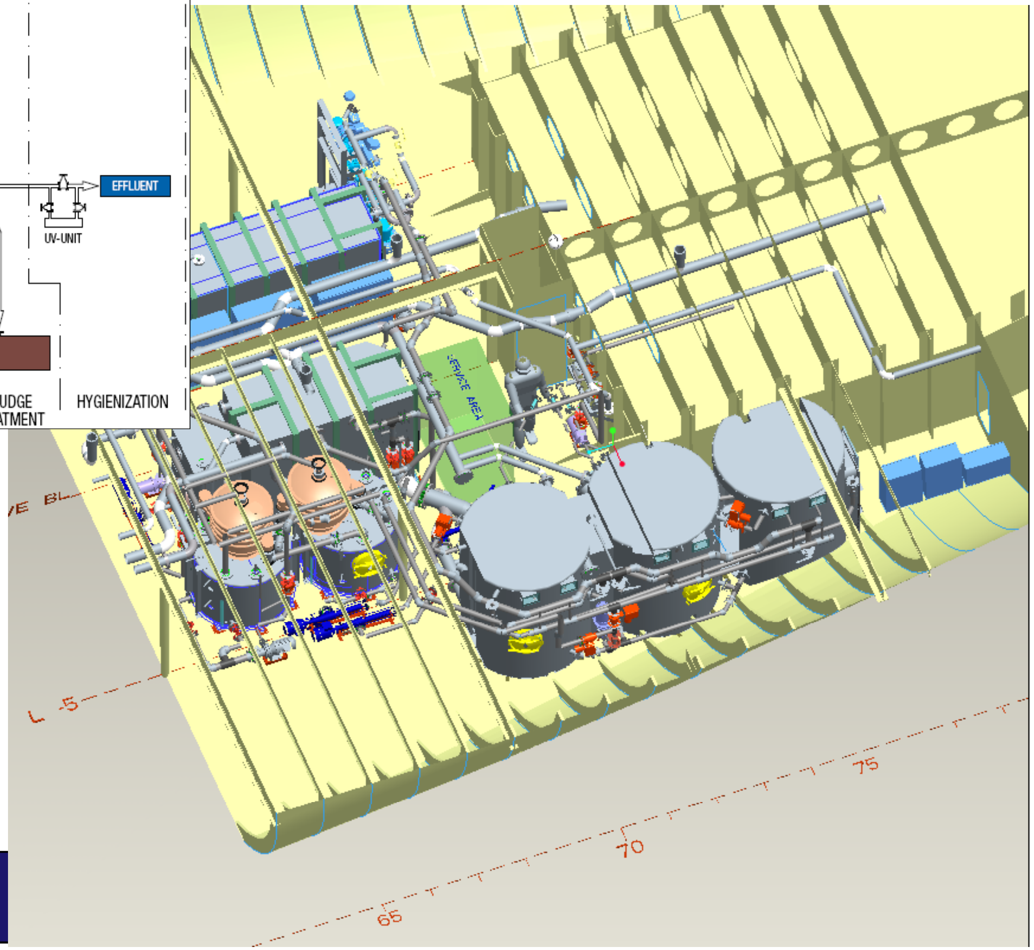


AWP process size

- Equalizing tanks normally as big as can be installed or found
  - Mixing by pumping
  - If proper size cannot be secured, waste water holding tank pumping must be controlled by timers
- Sludge holding depends the owner
  - 40m3/day from 5000pax with dry solid content of approx. 2% (screens 1/3 and bioprocess excess 2/3)
- Plus many intermediate pumping tanks + all the ”bells and whistles”

AWP is simple only in block diagrams





Example:

In this Evac MBR process case they found space for the bioreactor on a store space

3300 person Cruise ship

Source 2008 VTT/Baltic

Total dry weight of AWP process 83tons. Must be overhauled in pieces into engine room via hatches and water tight doors.

Energy cons: 204kW

Main components and electricity consumption (preliminary)

	Qty	Supplier:	Dry weight (kg)	Power cons (kW)
Main grey water transfer pump	2	Evac	108	4
Main laundry water transfer pump	2	Evac	52	4
Main galley grey water transfer pump	2	Evac	52	4
Aeration mixing for the MBR mixing tank (see option)		Evac		
Blower for the mixing tank		Evac	50	
Pretreatment equipment				
Vibro screen with double sieve	4	Evac	1864	7,4
Pump tank after screening	2	Evac	500	
Equipments for MBR				
MBR tank equipments (membrane cases, isolating valves etc.)	1	Evac	7500	
Blower	5	Rietsche	3690	150
Inverter for the blowers	5	Vacon	25	
Air distribution pipelines	2	Evac	65	
FBDA	140	Nopon	162	
Antifoam distribution pipelines	2		50	
Pressure transmitter	4	Gems		
Level sensor	15	Besta		
Foam detector with amplifier	5	Claris		
TSS sensor	2	Hach		
DO sensor	2	Hach		
Flow meters	3	Siemens		
Pressure switch	2	Gems		
pH meter	2	Hach		
Turbidity meter for effluent control	3	Hach		
Membranes ES 200 (Kubota)	10	Kubota		
Membranes lifting tool (Kubota)	1	Kubota		
Effluent tank (7 m^3)	1	Evac	770	
Foam trap tank (10 m^3)	1	Evac	1100	

3300 person Cruise ship

Source 2008 VTT/Baltic

In this case also a Denitrification tank accoridng to Baltic rules

Bioprcess 260m3 and Denitrification 70m3

Sludge holding for 3-4 days 140m3 (with aeration mixing)

Pumps				
Screen feeding pumps	4	Evac	292	7
MBR feeding tank pump	4	Evac	292	7
Sludge discharge pump	4	Evac	219	5,25
Effluent pump	2	Evac	108	7,2
Antifoam dosing pump	3	Evac		0,1
Alkali dosing pump	2	Evac		0,1
Sludge recirculation pump	4	Evac	108	7,2
Automation				
Master control unit	1	Evac	250	
Telemetry with remote monitoring, contolling & software loading	1	Evac		
Control panel for unit	1	Evac	50	
SC1000	1	Hach	5	
Local transfer pump panels	3	Siemens		
Frequency controllers for the pumps	12	Vacon	60	
Jets panel changes	4	Evac		
Chemical dosing				
Tanks	3			
Pumps	3			
Chemicals	2			
Valves and internal pipings				
Motor actuated valve	15		300	0,9
Solenoid valve	11		66	
Flow control valve	9		90	0,23
Pipings with elbows and T's	1		1500	
Valves	100		500	
Process and Sludge tanks & tank equipment				
47m3 Biotanks	2	Evac	11000	
78 m3 Membrane tanks	2	Evac	16000	
70 m3 Denitrification tank	1	Evac	18000	
70m3 sludge tanks	2	Evac	18000	
Aeration mixing for sludge tank	2	Evac		
			82828	**204**

AWP turnkey project steps

PLANNING AHEAD IS THE KEY FOR SUCCESS

AWP retrofit project steps
GENERAL
Accommodation and food onboard for installation crew
Fire watch
Electricity, gases, consumables, ventilation, heating, pr air, etc.
Lifting on and off of equipment/material from shipside
Garbage/trash disposal
Ship stability evaluation
Project manager
Travel costs
Freight costs to logistic centre to on board the vessel
Onsite installation supervision & management
Installation insurances and correct work permissions

AWP turnkey project steps

ENGINEERING TAKES NORMALLY LONGER THAN EXPECTED

ENGINEERING
Process design and component selection
Basic design of hull tanks
Detail design of hull tanks
Electric system design (basic + detail)
AWP automation system design (basic + detail)
Main Automation System (MAS) integration (basic + detail)
Type approval certificates required by Class and USCG
Modified ship's vents fills and sounding diagram
System internal piping diagrams
System external piping diagrams
Equipment arrangement plan
Ventilation drawings
Class approved material certificates and specs
Modified ship's tank and capacity plan
Penetration drawings for pipes, vents and electrical, both fire and water tight
Modified ship's damage control drawings
Modified ship's bilge and ballast piping drawings
Workshop drawings of foundations, prefabricated pipes etc.
Installation plan, schedule and procedures for equipment loading
Meetings and correspondance with class, authorities and owner
Project related classification fees

AWP turnkey project steps

COMPONENTS ARE RARELY ”OFF THE SHELF” => LONG LEAD TIME

EQUIPMENT AND MATERIAL
Steel for new tanks, tank modifications, foundations etc,
Piping (vent, waste water, effluent, sludge, aeration)
Penetrations
Damage control valves
Tools and tool storage
Scaffolding (support and work structures)
Biological and separation process units
Pumps, control panels etc. equipments related to pump units
Pre screen
Process tank aeration systems
UV units
Blowers (vent and aeration)
Defoaming system
Chemical dosing systems (pH control, coagulation, flokkulation etc.)
All valves
Sight glasses, vacuum interface valves etc. prefab components
automation equipment
MAS equipment
Gas monitoring system
Electrical equipment
Cables, cable trays, penetrations etc.
Paint

AWP turnkey project steps

LIMITED SPACE AND ACCESS + INSTALLTION DURING SHIP OPERATION PROLONGS THE INSTALLATION TIME

DEMOLITION WORK
Demolition and removal of existing units from installation location
Demolition of instruments, piping etc. from the existing tanks
Scrapped material / equipment outside the vessel
PREPARATION WORK
Protection of contracted spaces
Emptying, cleaning and gas freeing of installation related tanks
EQUIPMENT INSTALLATION WORK
Installation of equipments according to work specification
STEEL WORK
Building of new loose steel tanks
Steel work related to the existing tanks
Surface preparation related to the existing tanks
Coating of the existing tanks
Building of foundations for main equipment
Building of pump skids

AWP turnkey project steps

DESPITE GOOD ENGINEERING, LOT OF PIPING AND COMPONENT INSTALLATION NEED SKILLFULL IMPROVISATION

PIPE WORK	
Installation of waste water piping according to work specification	
Installation of sludge piping according to work specification	
Installation of effluent piping according to work specification	
Installation of vent piping according to work specification	
Installation of aeration piping according to work specification	
ELECTRIC WORK	
Cabling and installation of cable trays and penetrations, marking	
Connection of electric equipments to ship's systems	
AUTOMATION WORK	
automation system related work	
MAS related work	
COMMISSIONING	
Piping pressure and tightness tests	
FAT's	
Start-up, system testing, all manuals, etc.	
Training	
FINALIZING	
Final cleaning	
Touch-up painting	
Gratings, ladders, handrails, stairs and floorplates where necessary	

Constructional issues

- Low deck height causing issues
  - Oxygen transer
    - Nitrogen removal lead possibly into use of pure oxygen due to increased oxygen demand
    - Space for additional compressor and oxygen makers
  - Removal of large elements upwards
    - For example submerged membrane removal need space also upwards
  - Proper ventilation height above the bioprocess needed due to ship movements
  - ”Foaming space” and foam killing equipment

Constructural issues

- Transport routes
  - Large components must sometimes be cut into pieces to be able to transport them to their loctions
- On retrofit where prefabrication is impossible
  - It is difficult to work efficiently as there is no space to increase manpower around the AWP
  - Time consuming => expensive

Constructural issues

- Interfaces are most important for the cruise ships applications
  - Changing operation or components to previous collecting steps
- Use of structural tanks made for fuel or drinking water may not be optimum
- Sludge disposal routes and smell control
- Existing vent pipes, routing & water pockets
- Etc. Etc.

AWP Operation

- After the system installation and start-up it takes a while until the process is stabilized
  - Crew and system supplier need normally to fix various hot-spots onboard and make some fine tuning
- Suppliers with multiple installation know their process well. New comers face more various ”surprices”
  - Overall publiced data is nevertheless sufficient even for new suppliers to size their processes correctly
- Crew learn to ”play” with AWP feed, chemicals, holding capacities, test timing etc. => meet criteria when so needed

AWP Operational issues

- Smell
  - Ship is a closed structure and venting difficult
    - Ozone systems installed on worst vent pipes
    - If smell to the engine room area => smell control difficult => can leak to pax. areas
  - Prescreens not tight and need to be serviced
  - Sludge, foodwaste processing, foaming, leakages
- Chemical consumption
  - AWP's consume various chemicals
    - DAF chemicals expensive (feed shut on high seas)
    - Chemical feed => process hot spots

AWP Operational issues

- Sludge
  - Most of the organic waste from bioreactors is collected into sludge
    - Ships dump the sludge outside of 12nm according company policy
    - Most modern ships dry the sludge and burn it:
      - external dryers smell, spread sludge dust and consume energy
      - Internal incenerator dryers have huge problems with the ”glue fase” during the drying process
- Energy
  - Bioprocess must operate 24/7 even outside of Alaskan waters
  - Overall ecolocigal foot print always challenged !

AWP Operational issues

- Redundancy and hazards
  - Holding tank usage
    - Future Ballast water treatment rules in the future
    - Hydrogen sulfate creation in ”septic condition”
  - Start up period of biological process after hazard can take time
  - Space and cost versus 100% redundancy of mechanical components
- Hotel operations and US public health days
  - Chemicals (Chlorine for disinfection)

New Alaska rules

Ammonia

- Easier source defination (human activity)
  - Data on Nitrogen concentrations on influent already exist
- Nitrification/denitrification known to most AWP suppliers
  - Need more biosludge and oxygen
  - Separate denitrification step or usage of equalizing tank
  - Some older ships just run out of space !

New Alaska rules

Ammonia

- Partial reduction already on current AWP processes
- New Baltic rules support ammonia removal AWP integration
- Ammonia removal lead to better environmental practises as all waste water streams are more likely be treated

Hamworthy conserns

Ammonia Toxicity

Technical assessment - Challenges

Can BNR meet General Permit Ammonia limit? - trial is necessary.

- Ammonia is many times higher than that in municipal sewage (USEPA).
- Concentration fluctuations are far greater.
- Higher peak flow factors are to be allowed for.

- Black water can have 1000 mg/l ammonia, or higher with 'better' vacuum systems.
- Grey water dilute ammonia concentration.
- Higher temperature benefits the biological reaction rate - but there is a limit.

- Dedicated operation resource and skill base is required.
- Bioreactor size and footprint.
- Toxicity, alkalinity, foaming, vent capacity.

- Partial nitrification occurred to some MBRs.

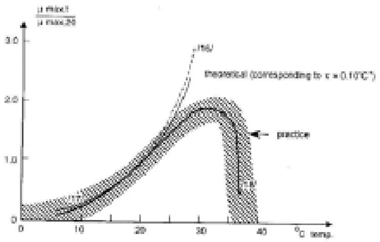


Fig 3.7 Nitrification as a function of temperature. As opposed to the other biological processes in wastewater treatment, thermophilic nitrifying bacteria are unknown.

Hamworthy

New Alaska rules

Metals

- All current data to be analysed properly !
- Proper tests on current AWP removal rates
- After source reduction most propably an add on technology
  - – Proper specification on challenge water (perhaps with 2 water qualities) to suppliers

New Alaska rules

Metals

- Specification to include Life cycle, maintenance, sludge etc. information requests
- As all suppliers would quote their system on same realistic specification, we would get better understanding on:
  - Overall Cost, Weight and Size of new technologies
  - Redundancy requirements of these new add-ons and issues related to operational problems.
  - Instrumentation needs
  - Alternative operational methods. Issues related to waste water holding and shore/sea discharge.

Conclusions

- What did we learn from previous:
  - Cruise Ship waste water is feed vary case by case due to:
    - Operational variations, ship size, route
    - Collecting and holding system variations
    - Operator views on waste water holding, treatment and sludge management
  - Current Alaska regulation can be met
    - the AWP sizing, operational and constructional issues are 99% under control

Conclusions

- AWP retrofit installation is always a compromise of cost, space and flow control
- Other new environmental rules challenge the AWP's
  - Low sulpher fuels/scrubber and ballast water management compete with AWP systems on tanks and space.
  - Ballast water management versus waste water holding are controversial if ballast tanks are used for holding treated waste waters.
- As waters treated, holding practises and sludge management vary between companies => Worse effluent quality may still mean higher environmental awareness and better technology => Can we judge the process purely on the end of pipe concentration results ?