HHI — Building a better future
Global Leader

Recent Development of Ballast Water Treatment Technologies
(2nd ASEF)

12th, November 2008.

Hyundai Heavy Industries Co., Ltd. Korea

2004 IMO BWM Convention

◆ International Convention for the Control and Management of Ship' Ballast Water and Sediments, 9 ~ 13 February 2004.

- To prevent the potential devastating effects of harmful aquatic organisms
- Require Ballast Water and Sediments Management Plan
  - Ballast Water Record Book
  - Ballast Water Management Procedure : Exchange and Performance standard

Constructed	BW Capacity	Year									
		08	09	10	11	12	13	14	15	16	17
Before 08'	< 1,500 m³		BWES or BWPS								
	1,500 ~ 5,000 m³		BWES or BWPS						BWPS		
	≥ 5,000 m³										
09' ~ 11'	< 5,000 m³			→	BWPS						
	≥ 5,000 m³										
After 12'	All					BWPS					

- Ships constructed in 2009 → not later than 31 Dec 2011 (IMO Assembly in Nov 2007, IMO Resolution A. 1005(25))

◆ Ballast Water Management Procedure

◆ Exchange Standard

Exchange		Standard
Volume	Volumetric Efficiency	at least 95%
	Pumping-Through	3 times volume
Area	Whenever possible..	200 miles land, 200 metres depth
	In case unable..	200 miles land, 50 metres depth
	Does not meet..	Designated area by port State

◆ Performance Standard

Organisms		Standard
Organisms	≥50㎛ min.Dim.	less than 10/m^3 viable
	10㎛-50㎛ min.Dim.	less than 10/㎖ viable
Indicator Microbes	Vibrio Cholereae	1cfu/100㎖ 1cfu/1g (wet weight)
	Escherichia coli	250cfu/100㎖
	Intestinal *Enterococci*	100cfu/100㎖

2004 IMO BWM Convention

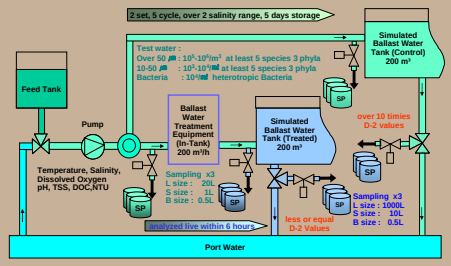
1. The most difficult and complex IMO instrument ever adopted.

2. Ratification : 30 countries representing over 35% of world tonnage.
   - As at 25 July 2008, 14 countries comprising 3.55% of world tonnage.
   - As of Oct. 2008, 16 countries representing 14.24% of world tonnage.
   - Existing ships will be required to do the same, but after phase-in period.

3. 35% of gross tonnage would be more difficult due to;
   - Unclear Guidelines
   - Limitation of cost effective viable technologies to treat ballast Water.

4. For the Development of Guidelines, concerns expressed;
   - Need for transparent type approval process
   - A single universe procedure needed to remove uncertainty to ships that their systems on board would meet the requirements of all ports.

2004 IMO BWM Guidelines



G8 Type Approval (MEPC 53, 58)
G9 Active Substance Approval (MEPC 53, 57)
G10 Technology Program Approval (MEPC 54)

(MEPC 55)
- **G1 Sediment Reception Facility**
- **G5 BW Reception Facility**

(MEPC 58) G2 Sampling

(MEPC 56) G7 Risk Assessment

(MEPC 56) G13 Additional Measures

(MEPC 55) G14 Designation of Exchange Area

(MEPC 53)
- **G3 Equivalent Compliance**
- **G4 Management Plan**
- **G6 Exchange**

(MEPC 55)
- **G11 Design & Construction**
- **G12 Sediment Control on Ships**

Source : KORDI

2004 IMO BWM Convention

1. For Ship owners ;

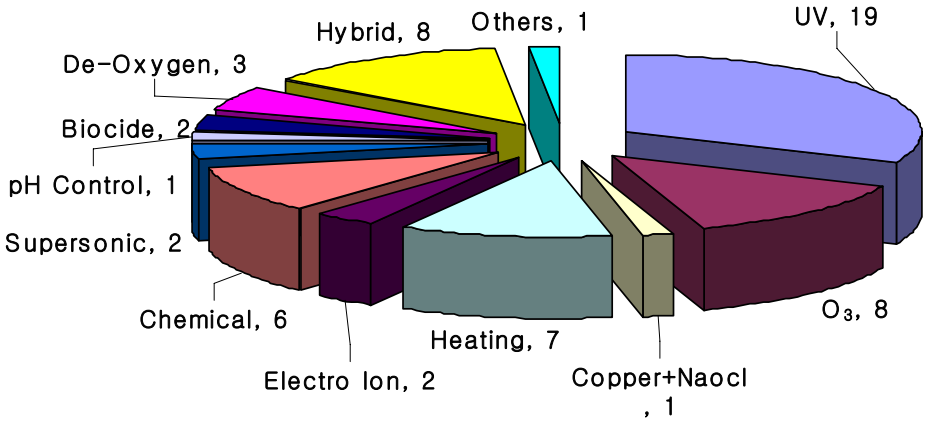
- Follow laws, regulations, guidelines and instructions
- Construction ship in line with the Convention
- Equip new and existing ships with type approved BWMS
- Prepare BW management plan and maintain Ballast water record book….

2. For Ship designers, Ship builders and Classes;

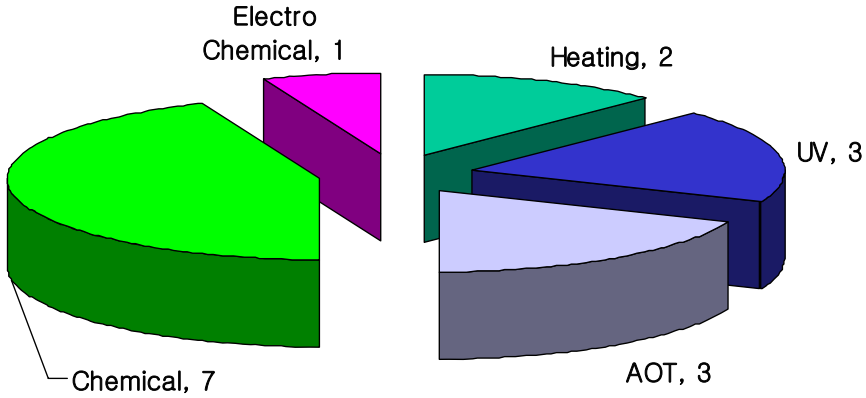
- Follow G6 for BW exchange in designing and building ships
- Follow G11 for BW exchange design and construction standards
- Follow G12 on design and construction to facilitate sediment control on ships
- Equip new ships with BWMS

Ballast Water Treatment Technologies

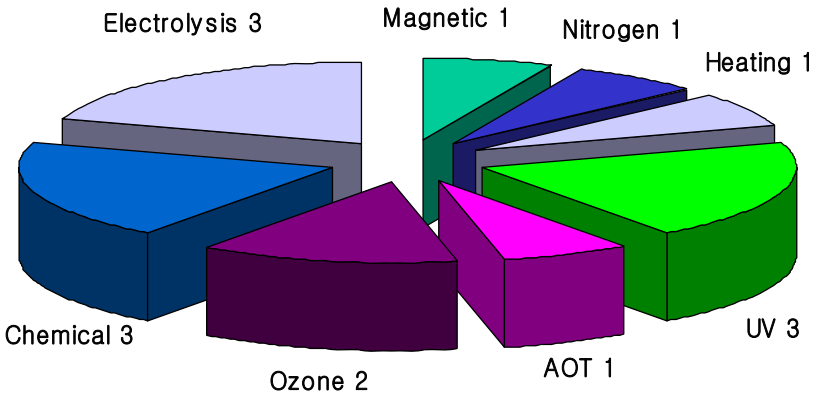
IMO Globallast (2003.5) Review



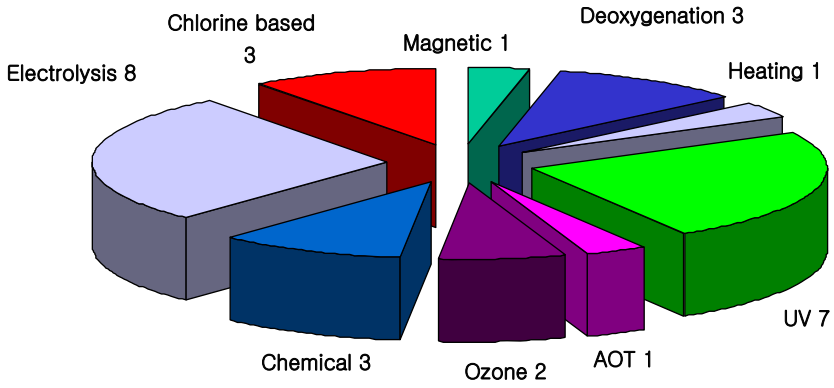
IMO MEPC 53 (2005.7) Review



IMO MEPC 55 (2006.10) Review

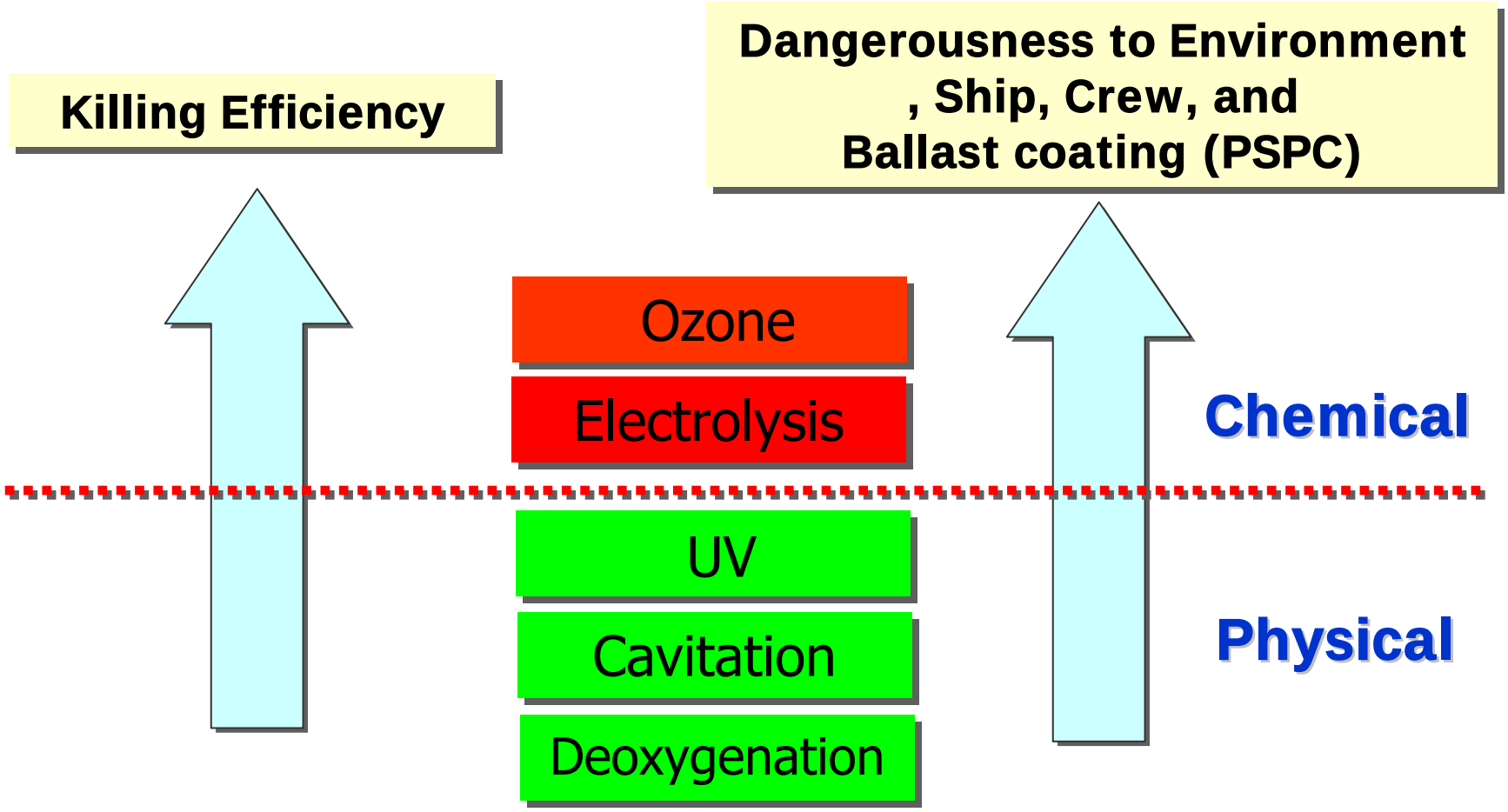


Lloyd's Register (2008.9) Review



Source : KORDI

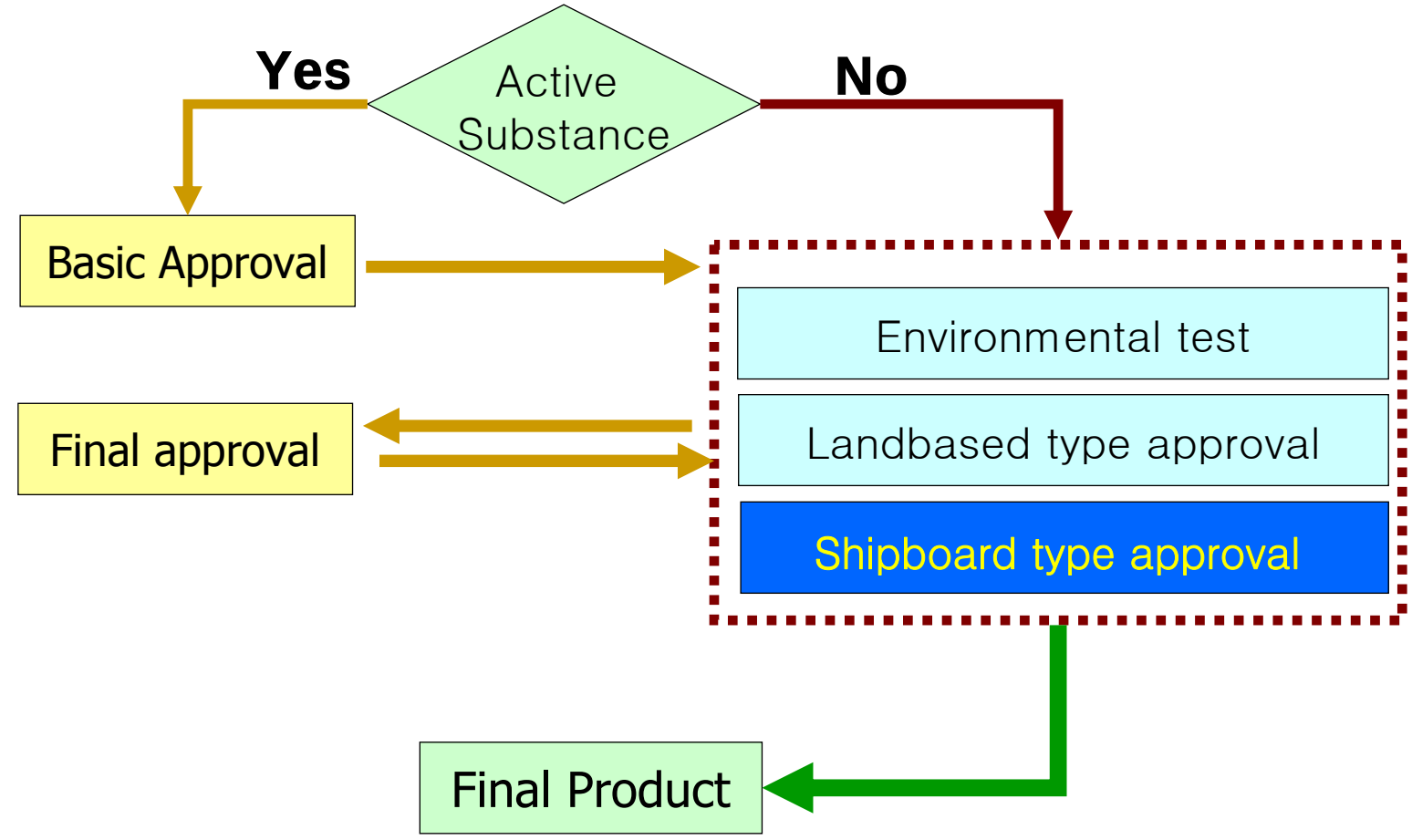
Ballast Water Treatment Systems



PSPC : Performance Standard for Protective Coatings

Tanks in conflict , Solutions and Newbuildings – Magazine, Fairplay, 07 Jun 2007

Procedure for BWTS Approval



BWTS IMO Approved System

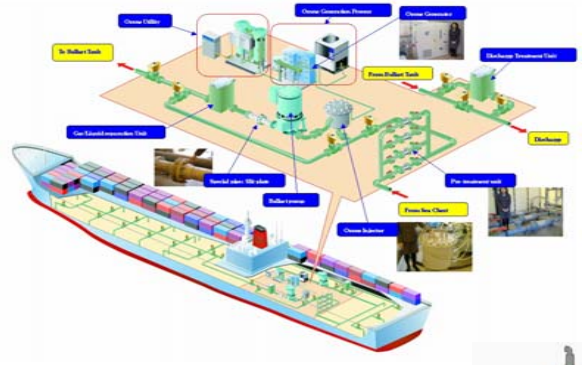
Basic	Developer		Technology	Final Approval
MEPC 54 ('06.3)	Korea	Techcross	① Electrochemical(10㎎/ℓ) ② Neutralization	MEPC58 ('08.10)
	Germany	Hamann	① Hydrocyclone/Filter ② PERACLEAN(150㎎/ℓ)	MEPC57 ('08.3)
MEPC 55 ('06.10)	Japan	Mitsui	① Filter ②Special Pipe(Cavitation) ③ Ozone(4㎎/ℓ)	
	Sweden	Permascand	① Filter ② Electrochemical (TRO 2㎎/ℓ)	RWO
MEPC 56 ('07.7)	Korea	NK	① Ozone (2.5㎎/ℓ)	
	Norway	Alfa Laval	① Filter , ② AOT	MEPC56 ('07.7)
MEPC 57 ('08.3)	Korea	Pan Asia	① Filter ,② UV	
	Japan	Hitachi	① Pre-Cogulation ② Magnetic Separation ③ Filter	
	South Africa	RBT	① Filter ② Electrolysis ③ Cavitation	
	Norway	OceanSaver	① Filter ② Cavitation ③ Electrochemical (TRO 2.5㎎/ℓ) ④ Deoxygenation	MEPC58 ('08.10)
MEPC 58 ('08.10)	Japan	Toagosei	① Filter ② Chlorination (FAC 30㎎/ℓ) ③ Neutralization (SS22㎎/ℓ)	
	Netherlands	GreenShip	① Hydrocyclone ② Electrochemical (FAC 3-10㎎/ℓ)	
	Germany	Ecochor	① Filter ,② Chlorine Dioxide (5㎎/ℓ)	

- Type approved system: Alfa Laval, Hamman AG, NEI, and others

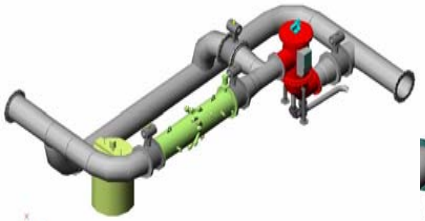
Source : KORDI

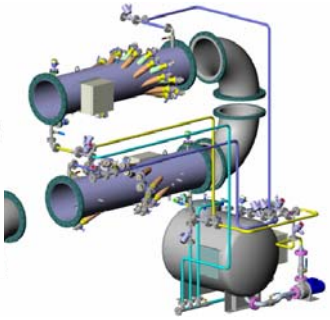
Ballast Water Treatment System

Ozone

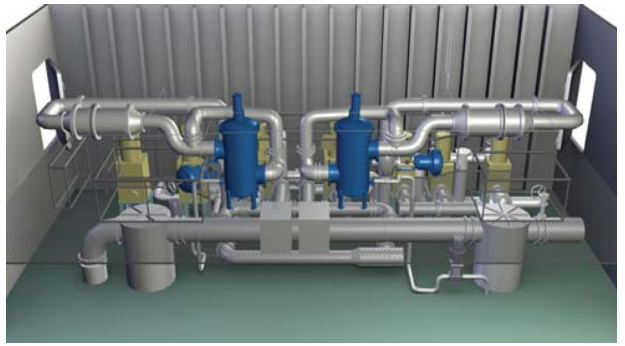


Filter + UV

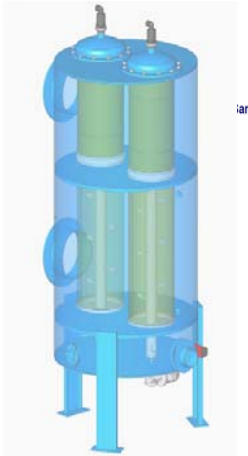




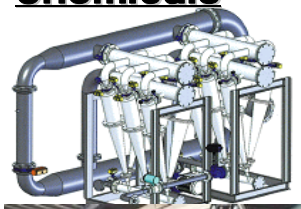
Seawater Electrolysis

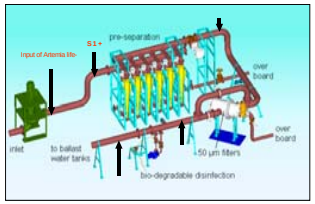


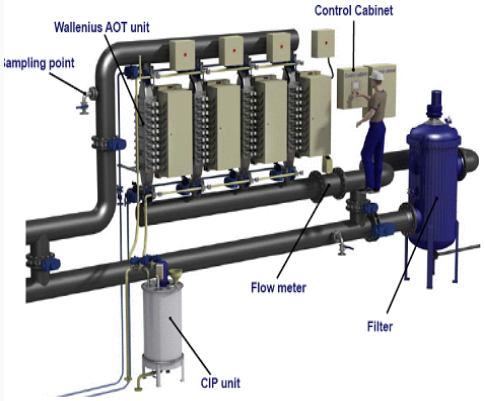
Deoxygenation



Chemicals



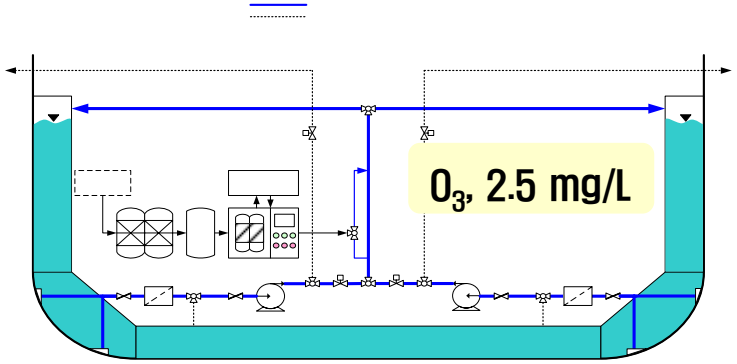




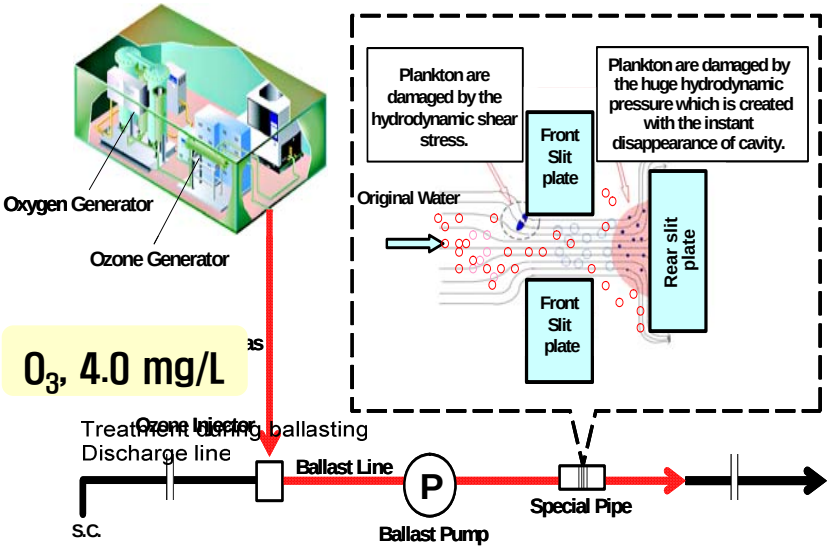
Ballast Water Treatment System

◆ Ozone Treatment

NK : O3 injection



Mitsui: fiter+O3+Special pipe

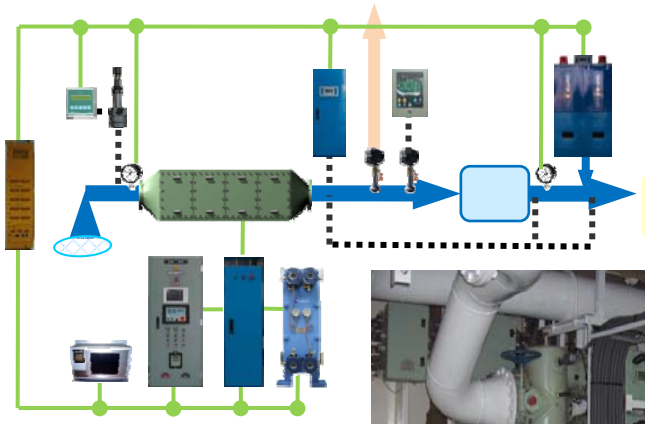


- Different O_3 concentration due to different water qualities
- Good killing performance
- Bromate formation, O_3 leakage : safety
- Neutralization unit

Ballast Water Treatment System

◆ Seawater Electrolysis

Techross : Direct electrolysis



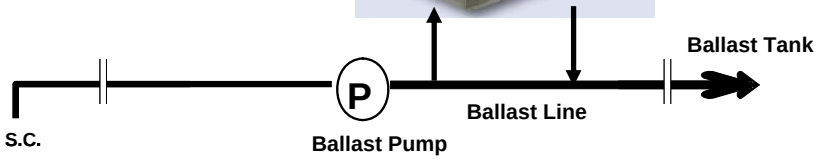
TRO : 10 ppm

OceanSaver : Filter + Cavitation + ID electrolysis

TRO : 2.5 ppm

STDN : Indirect electrolysis

NaOCl, 12 ppm

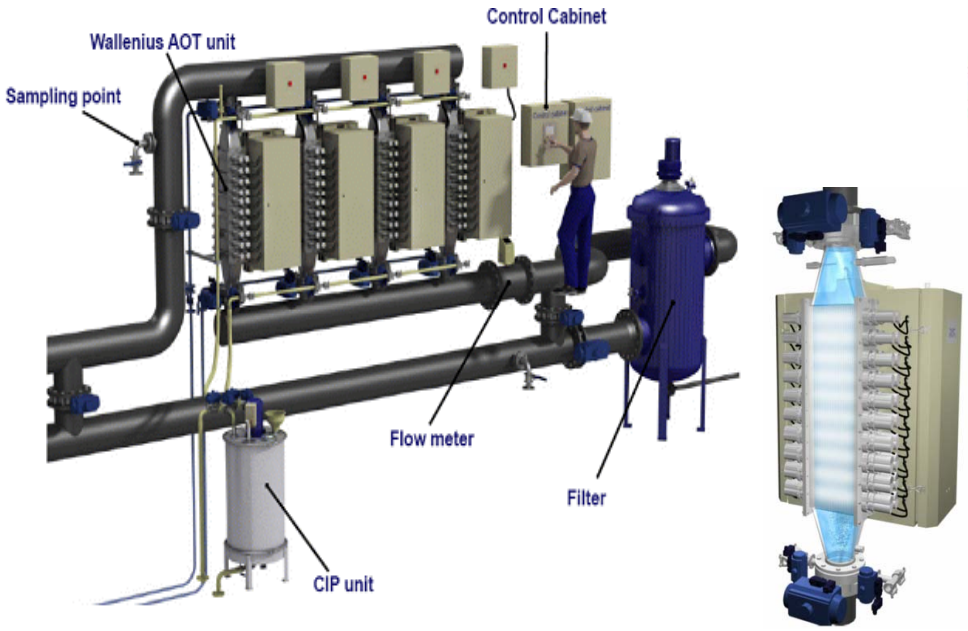


- Good performance
- Different TRO control with additional equipment
- Life time and scale control of electrolyzer
- Neutralization unit
- H_2 gas removal equipment

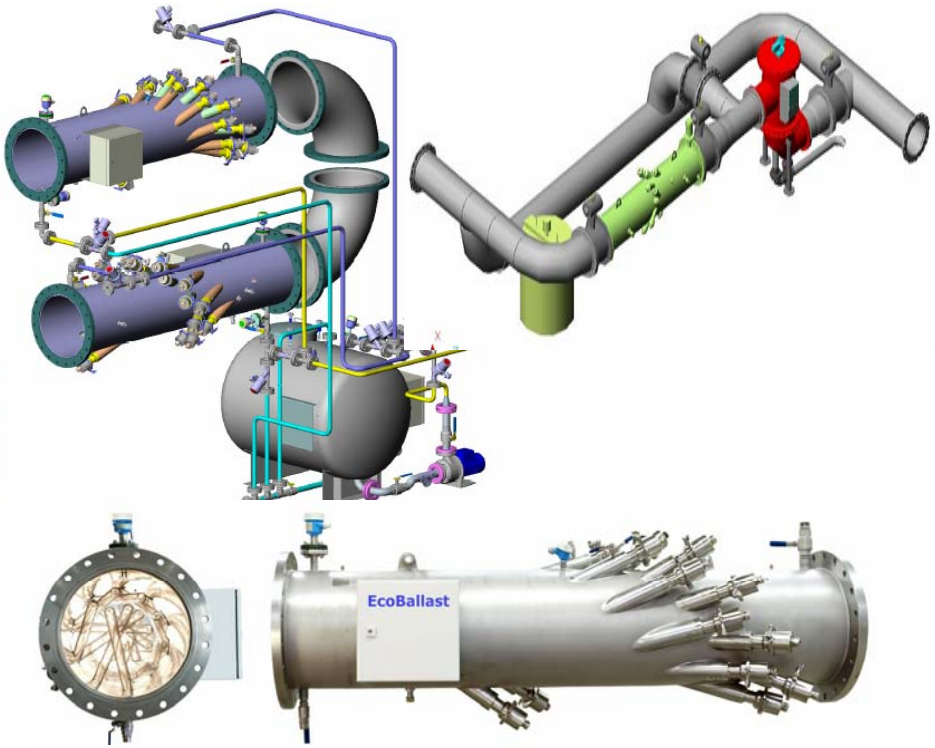
Ballast Water Treatment System

◆ Filter + UV

Alfa Laval: PureBallast

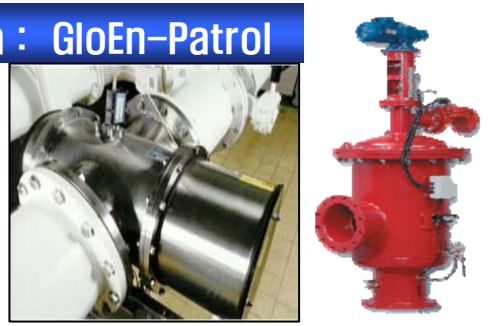


HHI : EcoBallast



- True environment-friendly solution
- Sediment control
- No residuals
- Life time of UV lamp
- Ballasting and deballasting, power consumption
- Small increase of Pump Head

Pan Asia : GloEn-Patrol



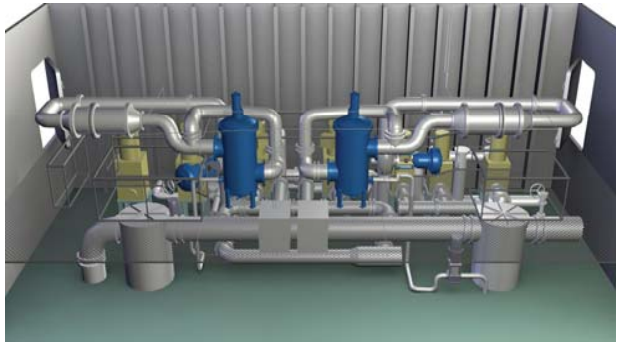
Ballast Water Treatment System

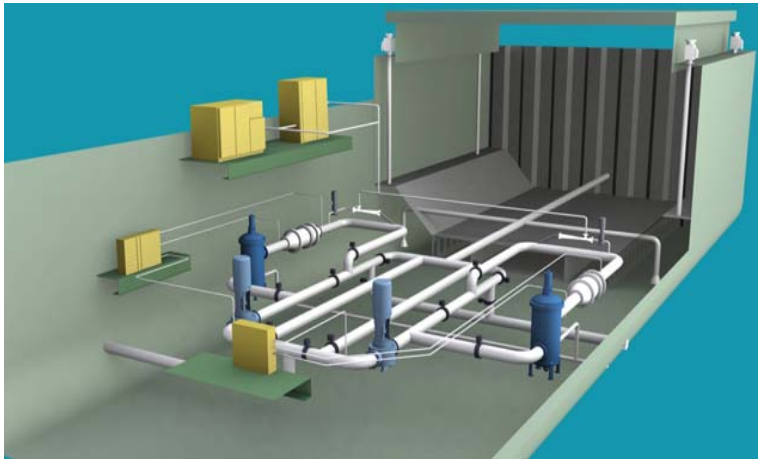
◆ Deoxygenation

NEI : VOS system

DO : 0.7 ppm

OceanSaver : Filter + IG Cavitation + ID electrolysis



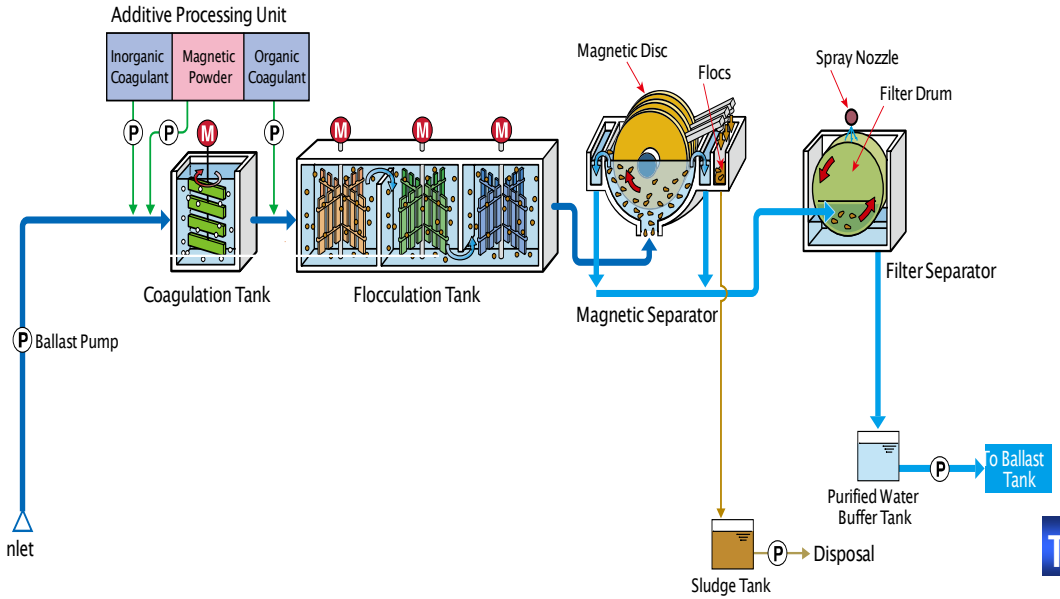


- Performance only with Deoxygenation (?)
- Maybe suitable for VLCC or LNG which already equipped with inert gas (N_2) generator
- Protection of corrosion (?)

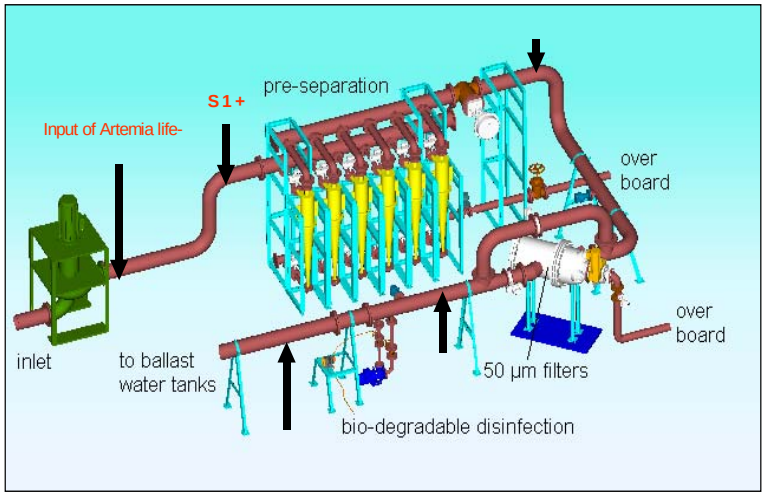
Ballast Water Treatment System

◆ Chemicals

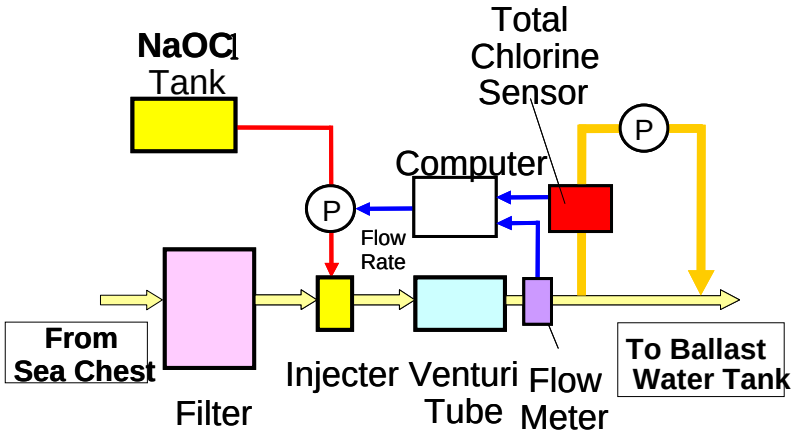
Hitachi : Cogulation + Magnetic Separation + Filter



Hamman AG : Peraclean (150ppm)



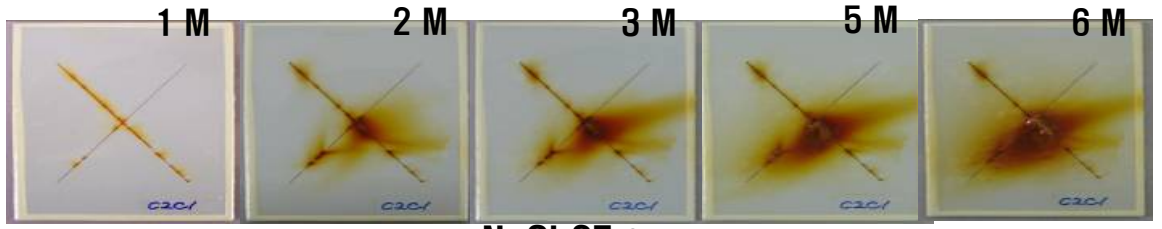
Toagosei : filter + NaOCl (20 ppm)



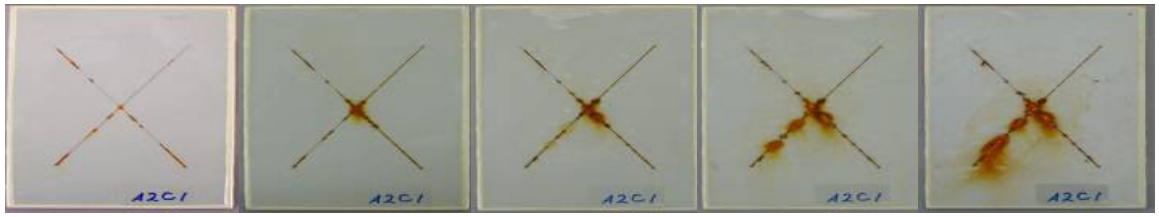
- Needs specific chemicals
- Some system has filter or cyclone
- Chemical supply and storage tank

Corrosion

◆ Seawater Electrolysis



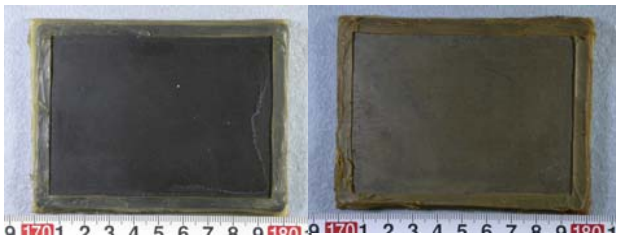
NaCl 25 ‰



TRO 25 ppm @ NaCl 25 ‰

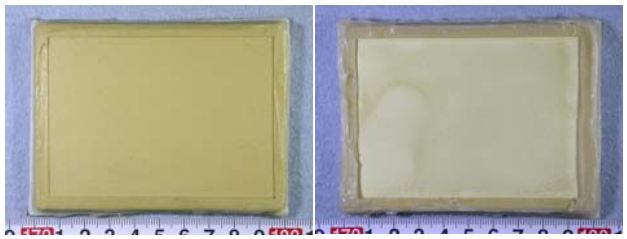
Source : Techross

Over a typical lifetime, exposure to hypochlorite at a concentration of 10 mg/l Total Residual Chlorine will not significantly increase ballast tank corrosion.
(MICHIGAN ENVIRONMENTL SCIENCE BOARD)



Seawater Seawater+20mg/l NaClO

Photo 6 Tar epoxy painted test pieces (after 340 days)



Seawater Seawater+ 20mg/l NaClO

Photo 7 Denatured epoxy painted test pieces (after 340 days)

Source : JEF

Over 340 days test with 7 days wet and 3 days dry, 20 ppm NaOCl, has no effect on painted steel and galvanized steel except for decolorization.

Corrosion

◆ Chemicals

▪ SeaKleen 2, 4 ppm, 30 days

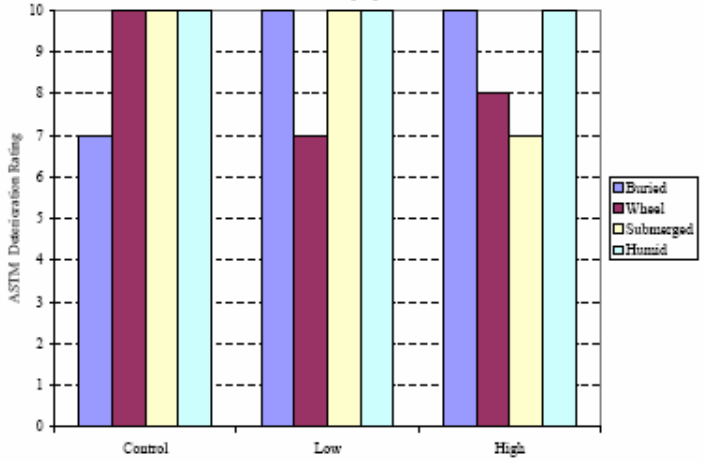


Figure 4.18(b): ASTM Score vs. Exposure (Average across all Coatings), 35 ppt Salt Water

▪ Peraclean 150, 300 ppm, 30 days

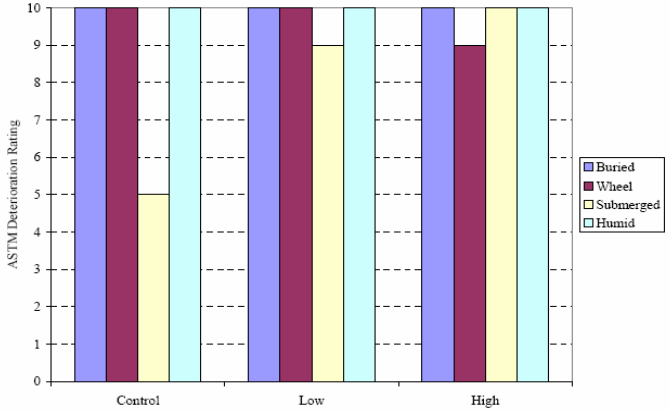


Figure 4.34(b): ASTM Score vs. Exposure (Average across all Coatings), 35 ppt Salt Water

◆ Deoxygenation

BMT Corrosion Rate Testing – 270 Days

Up to 85 % Lower Corrosion

Source : NEI

TREATED **UNTREATED**

Final technology decision(?)

In the Lloyd's Register's "Ballast Water treatment Technology, Current status, September, 2008"---

- Deoxygenation
  - Specially design for BWTS
  - Voyage length (1 ~ 4 days) is a factor in process efficacy
  - Relatively simple device if an IG generator is already installed
- Chemicals
  - needs (Peraclean, Seakleen, Chlorine dioxide) chemicals supply facility in ports
  - Power is very low and chemical costs will be a factor
- Electrolysis and Ozone
  - 2 mg/l residual chlorine is effective
  - Ozone dose of 1 ~ 2 mg/L is effective
  - Most have neutralizaton system
  - Electrolysis systme is the most complex system
- Filter + UV
  - Most UV system use medium pressure UV lamp
  - The water quality would be important factor
  - The least complex system to operate

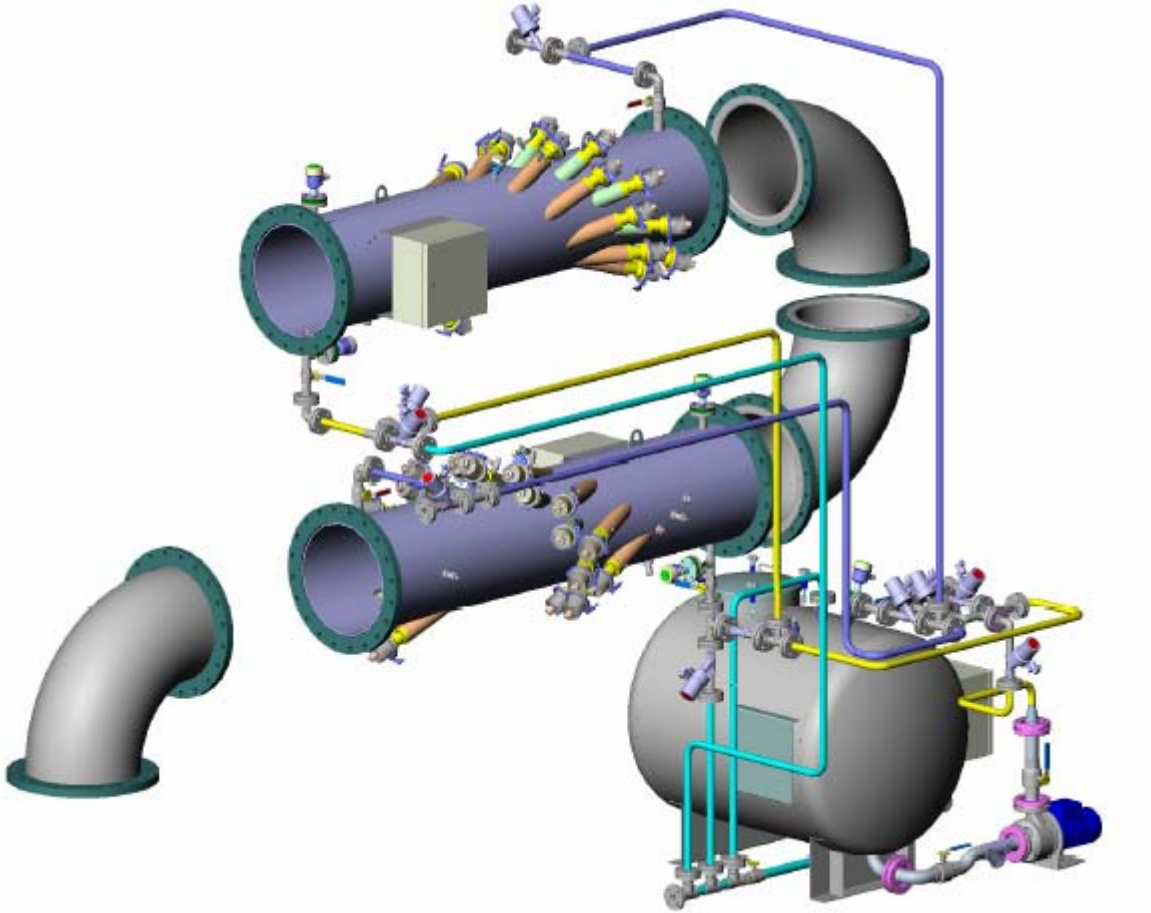
Final technology decision

	Ozone	Electrolysis	Filter + UV	Deoxygenation	Chemicals
Principle	O3	NaOCl	UV	Low DO	–
Additional piping works, footprint	○	○	○	○	▲
Increase of pump head	○	○	◎	◎	▲
Filtrate disposal	▲	◎, ▲	◎	▲	▲
Safety	◎	◎	▲	▲	◎
Corrosion	◎	◎	▲	▲	◎, ○
Installation cost	◎	◎	◎	◎	▲
Operation cost	○	○	○	○	◎
Performance	▲	▲	○	◎, ▲	▲

◎ important factor, ○ reasonable, ▲ not important (no problem)

☞ Still difficult to decide

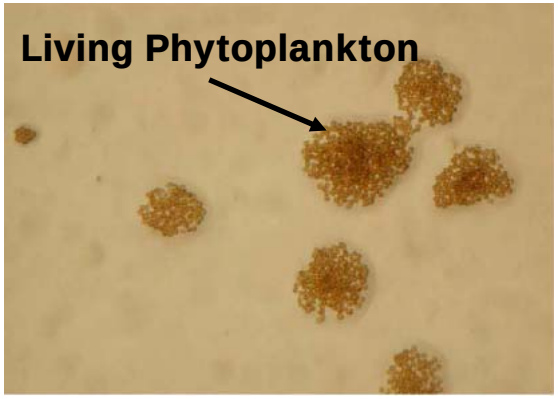
◆ HHI's UV-Technology : EcoBallast



◆ HHI's UV-Technology : EcoBallast

➢ 20 MP-UV lamps with treatment capacity more than 1,000m^3/hr

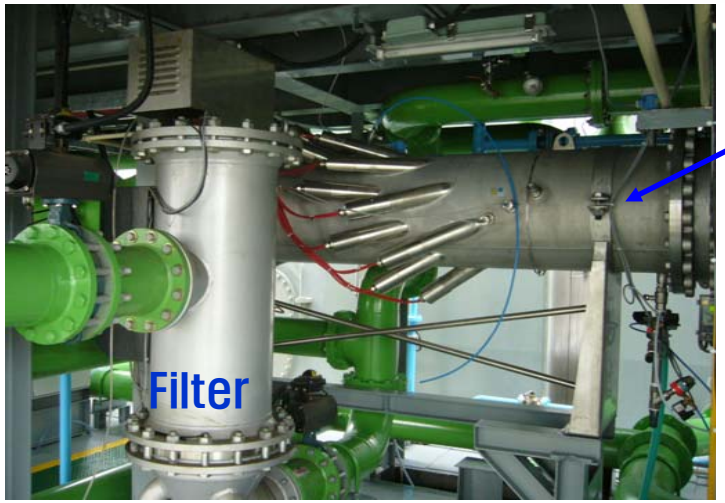
UV reactor Inlet



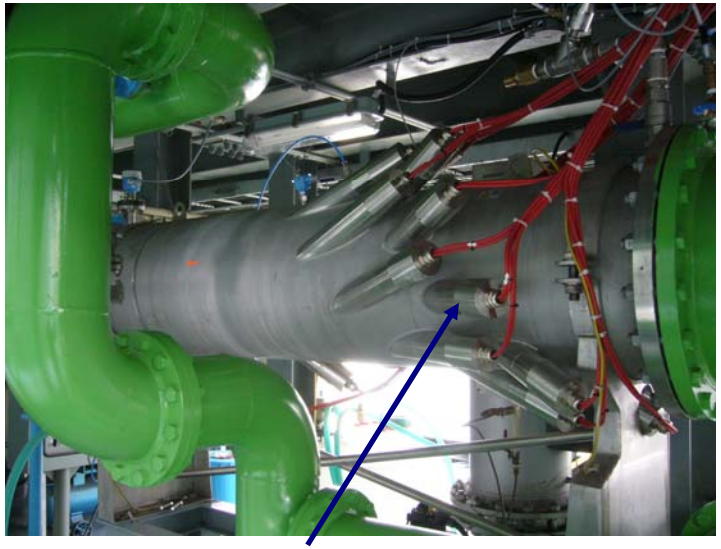
UV reactor Outlet

◆ Land-based test facility in HHI : 280 m^3/hr

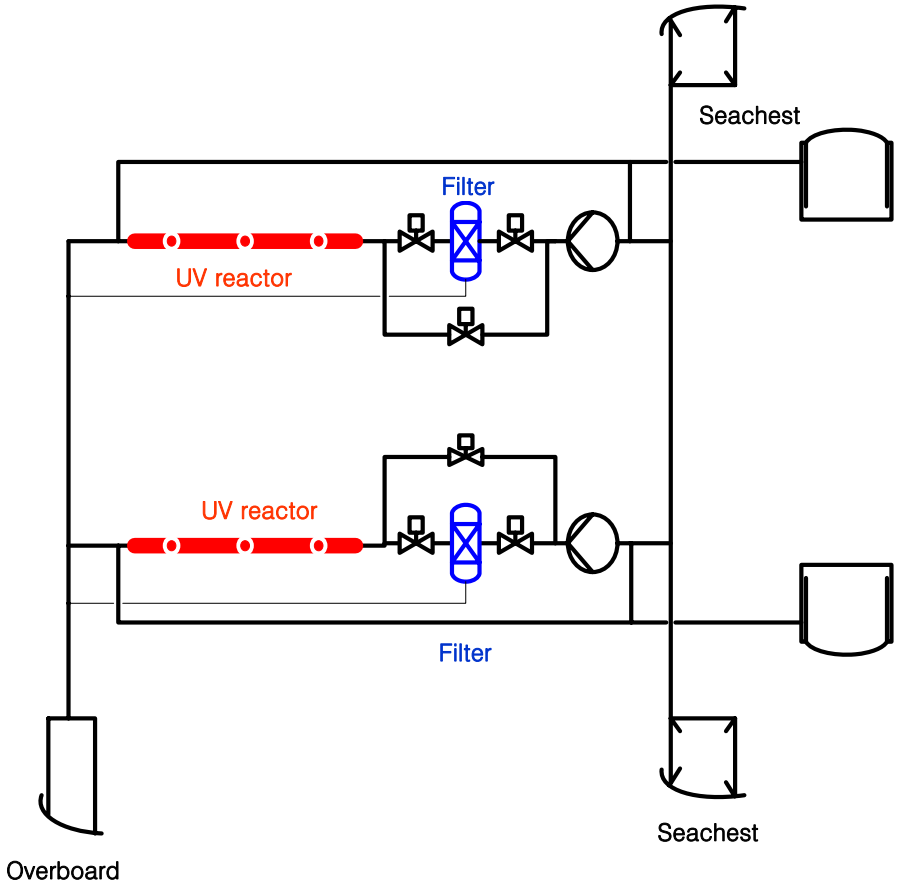


UV Reactor

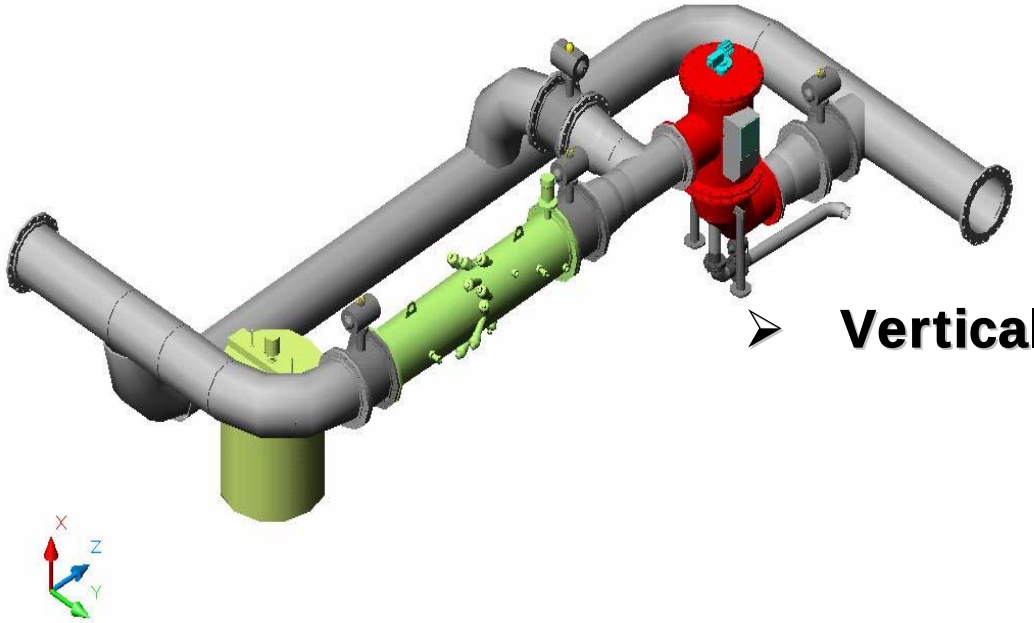


UV Lamp

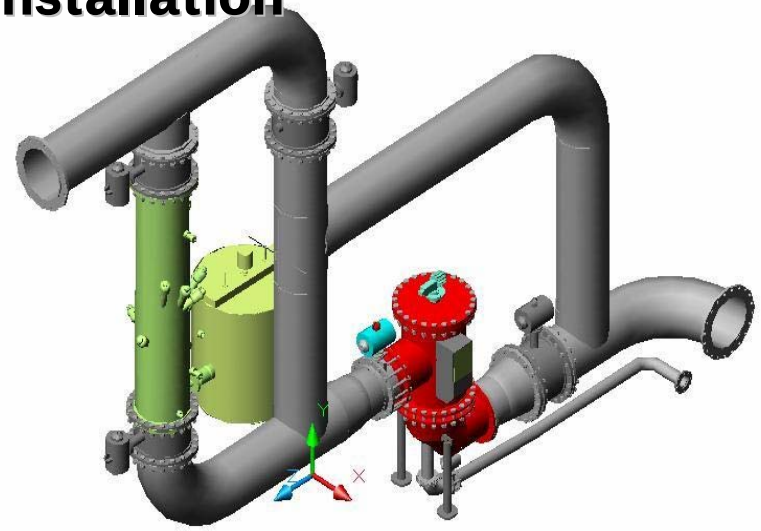


◆ Installation in Vessel

➢ Horizontal Installation



➢ Vertical Installation



Thanks for your attention