Rajesh Madusudanan

7th EMship cycle: October 2016 – February 2018

Master Thesis

Ballast Water Treatment Systems: Type Approval, Certification, Comparison and Retrofitting Ship

Supervisor: Prof. Zbigniew Sekulski, West Pomeranian University of Technology, Szczecin, Poland
Internship tutor: Mr. Andrzej Sobieraj, Westcon Design Poland, Szczecin, Poland
Reviewer: Prof. André Hage, University of Liege, Liege, Belgium

La Spezia, February 2018

CONTENTS

1. Westcon Design Poland, Szczecin (Internship)

Preparation of technical documentation for all design stages

- New buildings

- Existing vessels: conversions, retrofits, upgrades

- Offshore vessels/Platforms

Overseas Marine Certification Services - OMCS Class, Panama

- Recognized Org. + Recognized Security Org. – Panama Maritime Administration

- Services: Ship Classification, Statutory Certification, Verification & Consultancy

- Recognized by 13 flag states

- Head office: Panama, Regional Offices: Dubai, Shanghai, Canary Islands

2. INTRODUCTION

Objective and Scope

- study about IMO and USCG regulations for ballast water management, salient features, type approval procedures and comparison
- brief description and comparison between most widely used treatment methods, alternate and innovative solutions, important factors for the selection and installation of an appropriate treatment system
- case study - retrofitting ship
- comparison and analysis at various stages and conclusions are drawn, recommendations to various stakeholders, future prospects
- Scope - limited to available data from the associated industry

3. IMO REGULATIONS FOR BALLAST WATER MANAGEMENT

Key Requirements

- Ballast Water Management Plan (BWMP)
- Ballast Water Record Book (BWRB)
- International Ballast Water Management Certificate (IBWMC)

D1 Ballast Water Exchange Standard

- Atleast 95% of volumetric exchange or if using the pumping through methods, three times the volume of each tank

D2 Ballast Water Performance Standard

- Viable Organism (Plankton) ≥ 50μm: < 10 cells per m3
- Viable Organism (Plankton) 10-50μm: < 10 cells per ml
- Toxicogenic Vibrio Cholera (O1 & O139): < 1 cfu per 100 ml or < 1 cfu per 1g zooplankton samples
- Escherichia Coli: < 250 cfu per 100 ml
- Intestinal Enterococci: < 100 cfu per 100 ml (cfu: colony forming unit)

Complying with the Ballast Water Management Convention

Stopping the spread of invasive aquatic species

IMO INTERNATIONAL MARITIME ORGANIZATION

D1 standard requiring ships to exchange ballast water in open seas, away from coastal areas. Few organisms survive.

D2 standard specifying the maximum amount of viable organisms allowed to be discharged, including specified indicator microbes harmful to human health. Usually involves installing ballast water management system.

BACKGROUND INFO

- All new ships must conform to the D2 standard.
- Until the date when they have to meet the D2 standard, existing ships should exchange ballast water mid-ocean, to meet the D1 standard.
- Over time, all ships will have to meet the D2 standard.
- 'Renewal survey' refers to the IOPPC renewal survey under MARPOL Annex I

All ships must have:
- ballast water management plan
- ballast water record book
- International Ballast Water Management Certificate

2017

Existing ships built prior to 8 September 2017 must meet the D1 standard until their D2 compliance date.

New ships built on or after 8 September 2017 must meet the D2 standard.

2019

Existing ships with renewal survey between 8 September 2017 and 8 September 2019

Case 1: if previous renewal survey was between 8 September 2014 and 8 September 2017 – must comply with D2 by this renewal survey.

Case 2: if previous renewal survey was before 8 September 2014 – then compliance with D2 must be by the next renewal survey.

Existing ships with renewal survey after 8 September 2019 must meet D2 standard by this renewal survey.

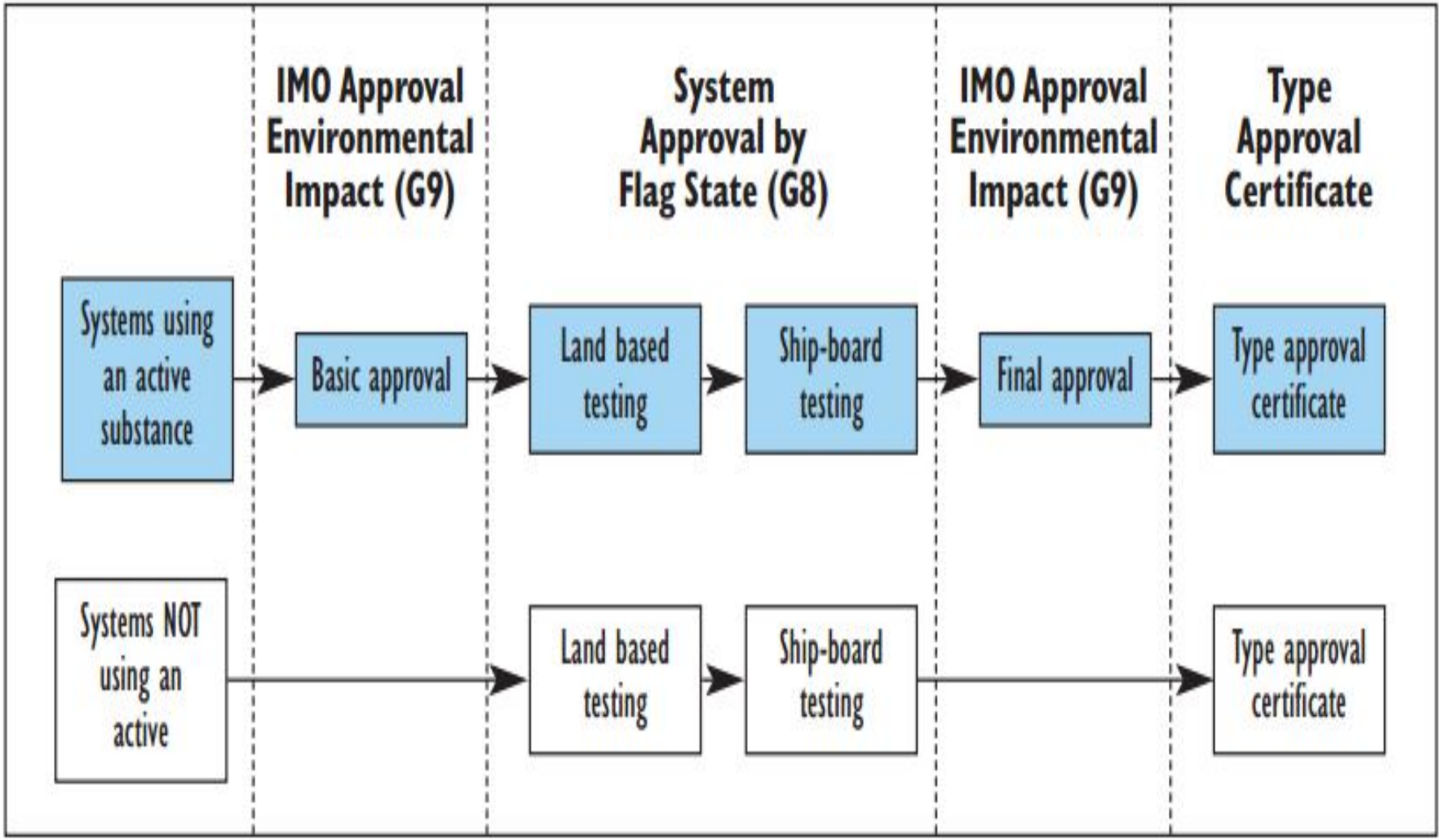
2024

All ships must meet D2 standard by 8 September 2024.

D2 STANDARD

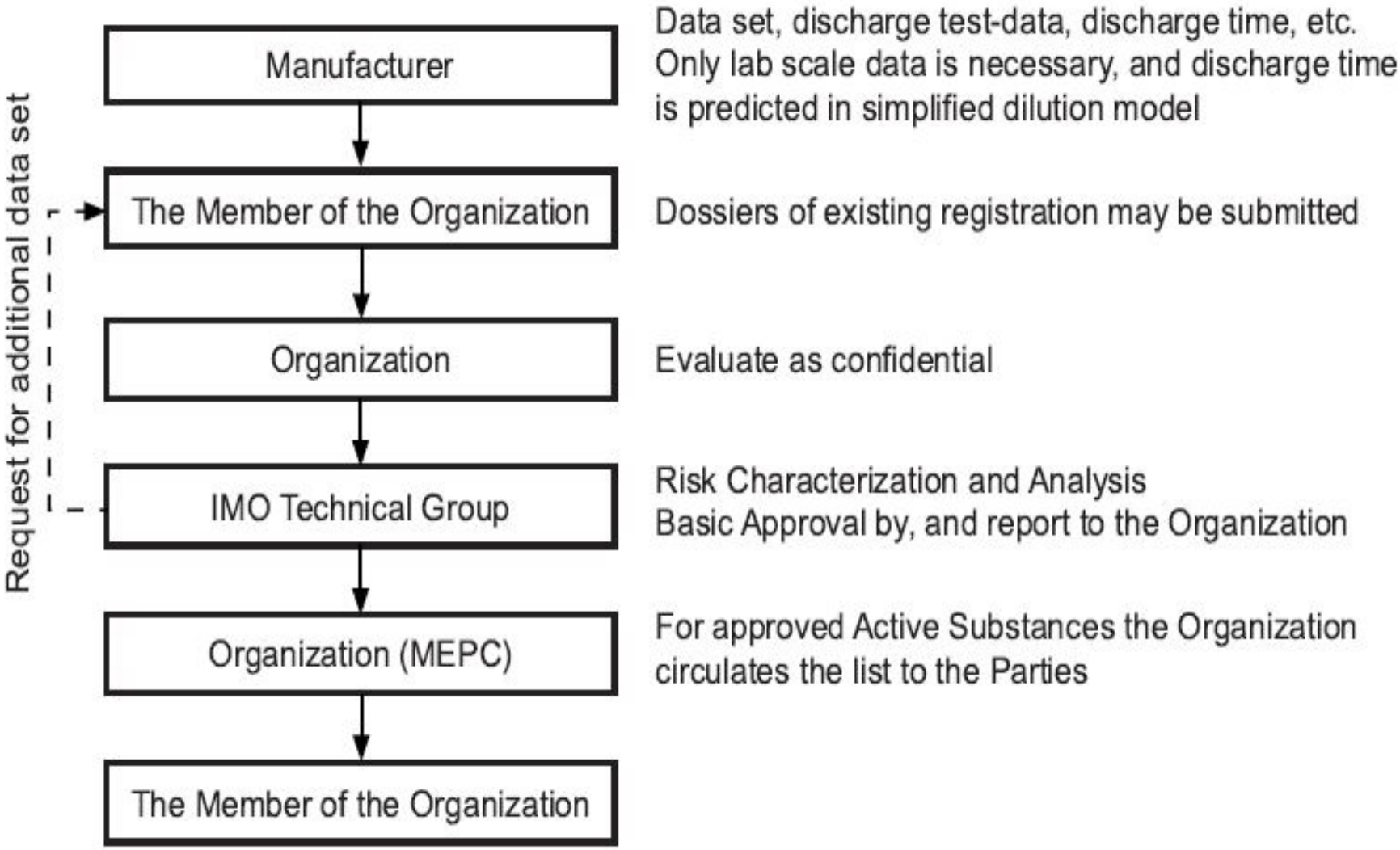
D1 STANDARD

Type Approval



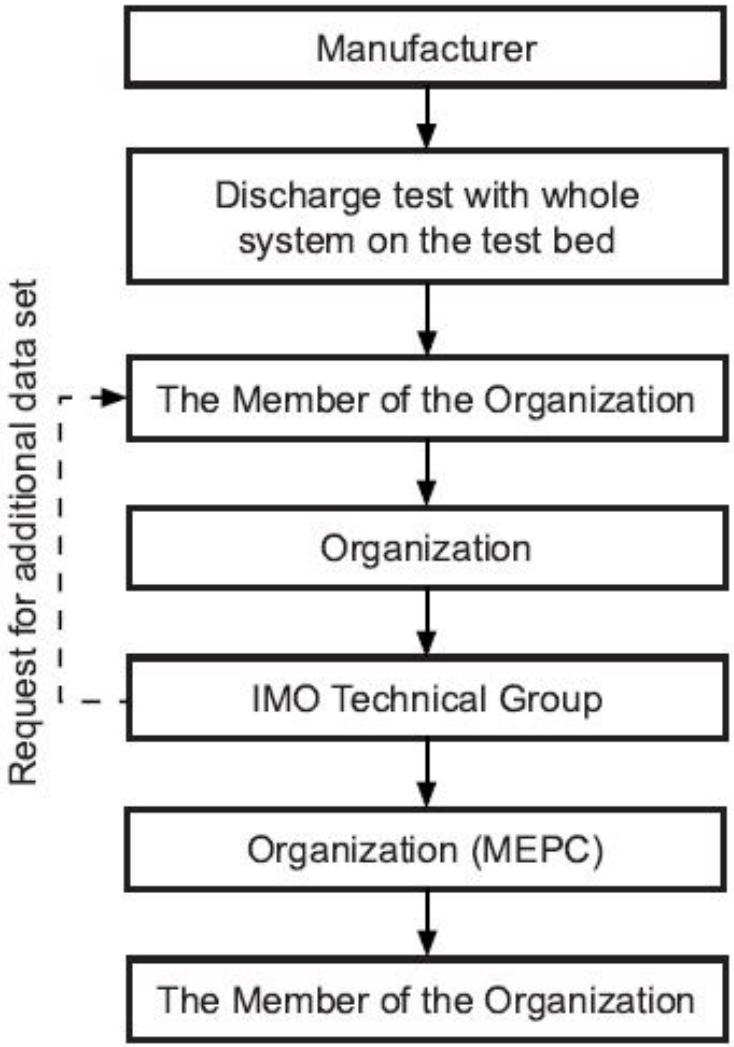
Source: BV/G8 & G9 Guidelines

Basic Approval



Source: BV/G8 & G9 Guidelines

Final Approval



Data set, discharge test-data, discharge time, etc.
Using Active Substances that have received Basic Approval

Type Approval according to relevant IMO guidelines

Confirm residual toxicity of discharged ballast water with the evaluation under the Basic Approval

Approve the Ballast Water Management system that makes use of Active Substances

Publish list of approvals

Source: BV/G8 & G9 Guidelines

4. USCG REGULATIONS FOR BALLAST WATER MANAGEMENT

- Key Requirements – USCG Approved system, Self-monitoring records, Other accepted methods-Extension from USCG, Alternate Management System (AMS), Uptake from US public water system, Discharge to reception facility, No discharge in US waters as per BWMP

- AMS - temporary solution until USCG approval, not equivalent to USCG approval, valid for 5 years

- Compliance Schedule, Exemptions & Extensions

- Approval procedures – Letter of Intent, IL, Submission of Application, Evaluation of application, Environmental evaluation, Eligibility for approval, Issue of approval certificate

- Independent Laboratories (IL) & Sub-laboratories

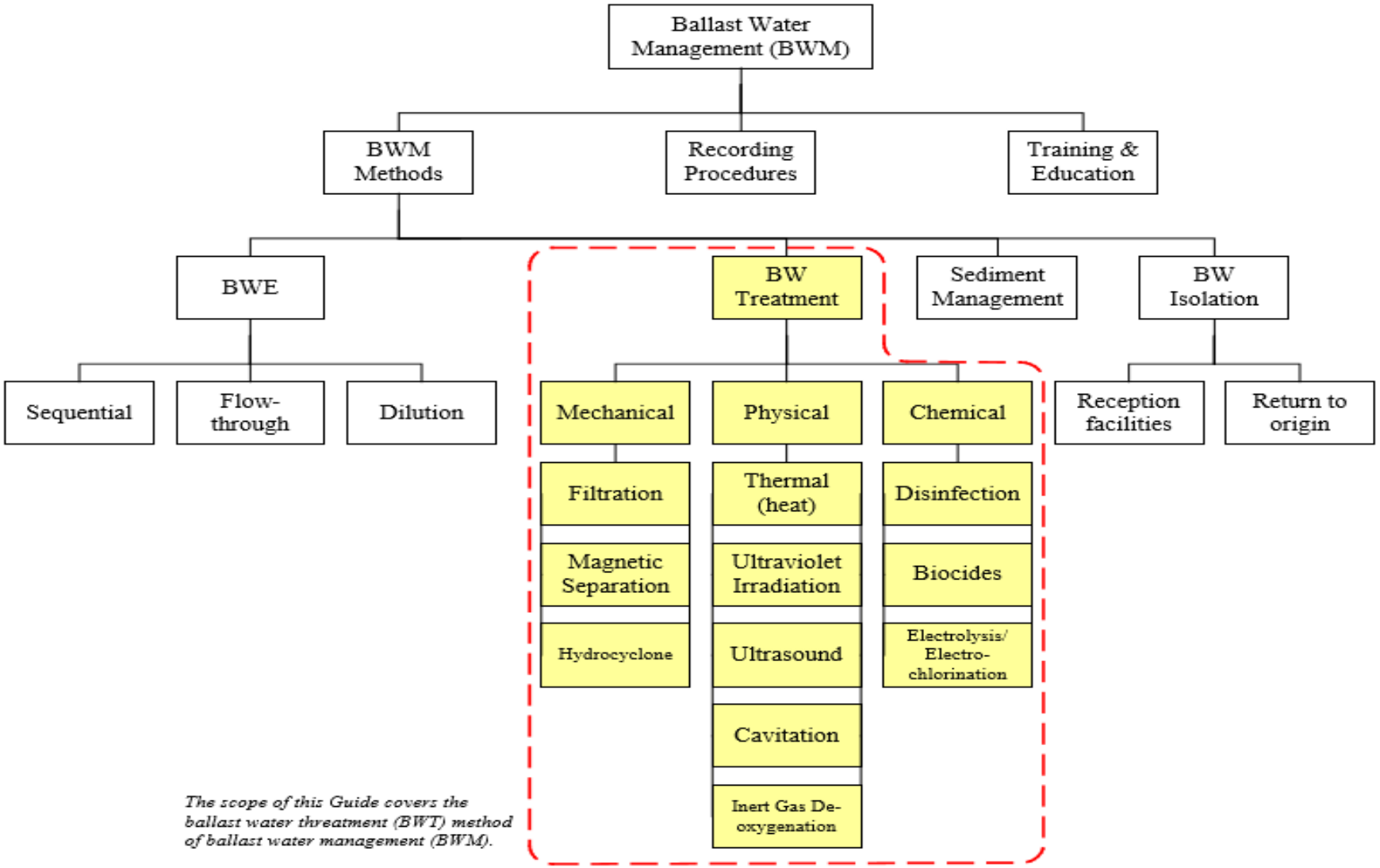
- Approval status – 6 systems approved, 2 systems pending (7th Nov 2017)

5. COMPARISON BETWEEN IMO & USCG REGULATIONS

Description	IMO	USCG
Requirements	IMO	Federal & EPA's VGP
Compliance Schedule	Depends on date of construction, IOPP renewal survey date	Depends on BW capacity, date of construction
Certificate requirements	Only one (Flag approval)	USCG approval or AMS
Approval by	Flag (or Class onbehalf of Flag)	USCG
Operator for testing	Manufacturer	IL
Laboratory for testing	Any competent lab	Approved ILs only
Observation of testing	Self-observed by lab	Observed by IL
Reporting of results	Manufacturer/Lab	Reported to USCG by IL
Testing methods required	G8/G9 Guidelines	ETV Protocol only
Accepted test method	MPN method accepted	MPN method not accepted
Biofouling & Sediments	Not very stringent	Stringent

Ref: Lloyd's Register

6. BALLAST WATER TREATMENT TECHNOLOGIES



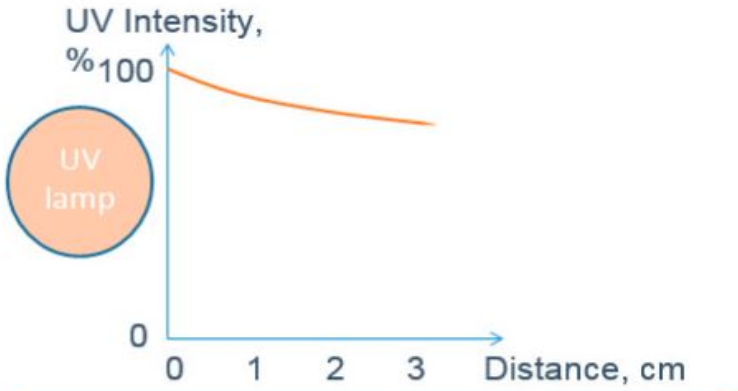
Source: American Bureau of Shipping

Comparison between UV & Electro-Chlorination

Parameters	UV	Electrochlorination
Technology	Electrical	Chemical
No. of sensors	Less	More
Hazards	Related to Electrical	Related to Chemical
By-products	No	Yes
Neutralization	Not required for discharge	Required for discharge
Capital Expenditure	Lower	Higher
Suitability	Low volume of ballast water	High volume of ballast waters
Salinity	Works in all salinity	For fresh water, additional salinity required
Power Consumption	Disinfection 0.045-0.063 kW per m^3	Disinfection 0.014-0.042 kW per m^3, Fresh and Cold water treatment ~2-4x Higher
Chemical costs	CIP (Clean-in-place) or Physical Wiper Cleaning	Neutralization chemicals, Supplement for fresh water treatment
Cleaning costs	Automatic Lamp Cleaning, Filter Backwash	Hydrochloric Acid Cleaning of Electrode Scaling, Filter Backwash
Replacement costs	Medium-pressure Lamp Replacement (~3 Yrs)	Electrode Replacement (~5 Year Life)
Planned Maintenance	Inspection, Lamp Replacement	Inspection, Electrode Replacement
Unplanned Maintenance	Manual Filter & Lamp Cleaning	Premature Tank Coating & Seal Failure, Manual Filter Cleaning
Calibration costs	UVI Sensor Calibration	Total Residual Oxidants (TRO), pH, Temperature, Turbidity, Sensor Calibration
Compliance costs	Discharge Sampling Only	Discharge Sampling + Additional TRO & Disinfection By-product Sampling
Training costs	New Operator Training	New Operator Training, Chemical Handling & Safety
Safety costs	No Additional Safety Provisions Required	Hydrogen Gas Management System

Ref: Trojan Marinex

UV-Transmission:



UV-T = 90% (90% of light remains after penetrating 1 cm into water)

UV-T = 50% (50% of light remains after penetrating 1 cm into water)

Distance from UV lamp [cm]	UV-T = 90% UV intensity [%]	UV-T = 50% UV intensity [%]
0	100	100
1	90	50
2	81	25
3	72.9	12.5

Port	UV-T
Shanghai[i], China	49
Vera Cruz, Mexico	94
Houston, USA	74
New Orleans, USA	54
Shanghai[i], China	55
Hong Kong, China	80
Antwerp, Belgium	66

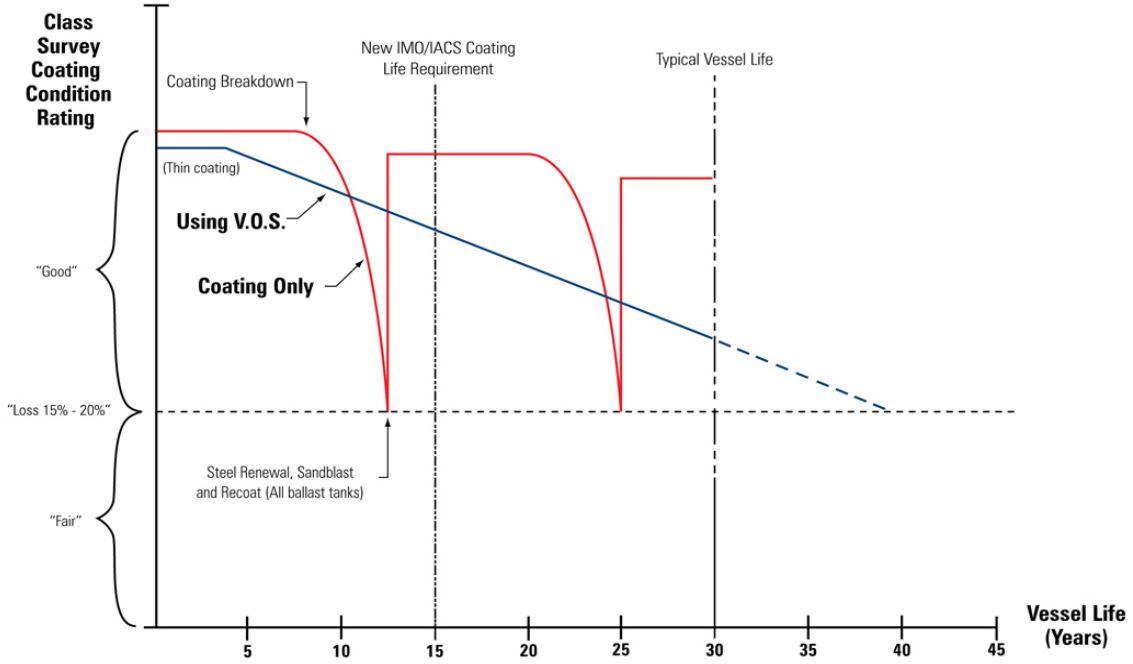
Source: DESMI Ocean Guard

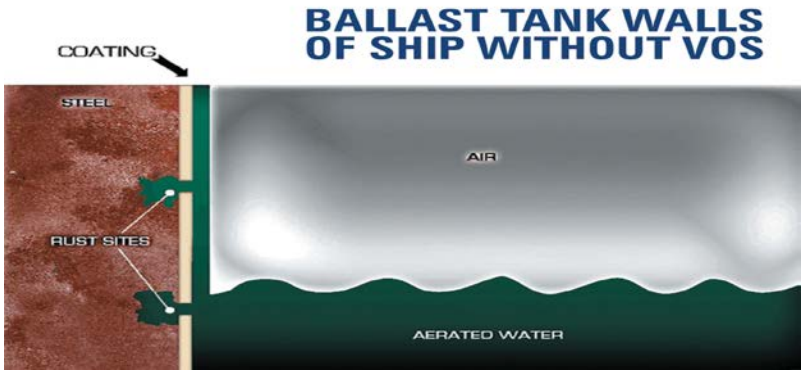
Disinfection by-products (DBPs) - Chemical disinfection methods + Health impact

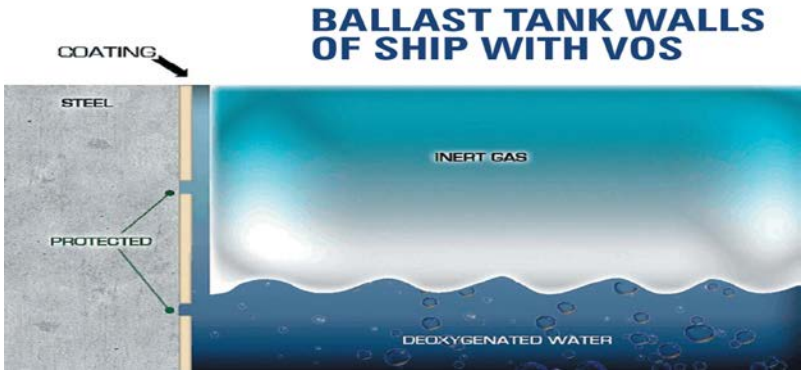
De-oxygenation & Corrosion Effect

Source: NEI Treatment systems

VOS™ SGG-5000 Stripping Gas Generator







Alternate BWMS

(i) ***Port reception facilities*** - Ballast Water can be received in port through the reception facilities. BWMC, B.3.6 [1] states that the regulations of this convention do not apply to ships which have opted to such facilities.

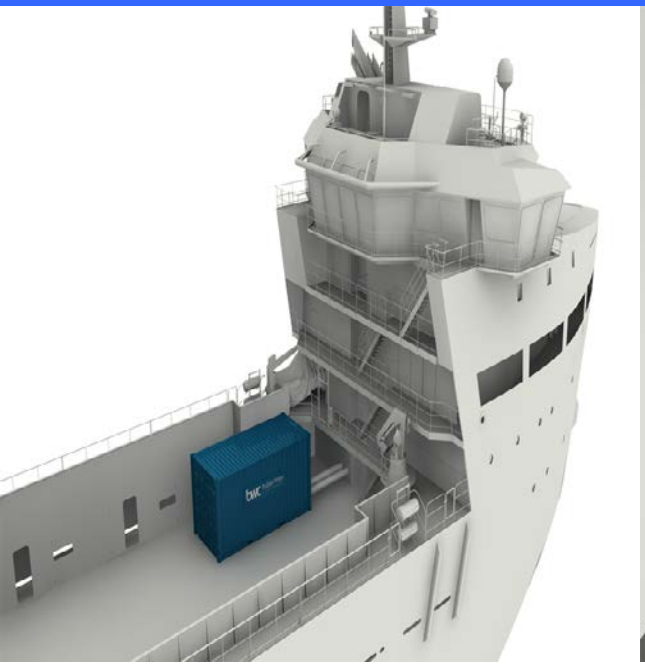
Requirements - Technical Guidelines for Ballast Water Reception Facilities G5 [Resolution MEPC.153(55)]

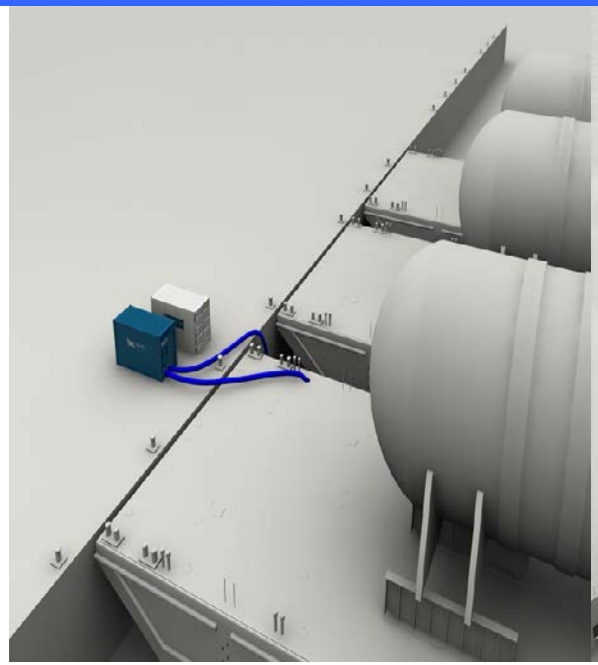
(ii) ***No Ballast Ship Concepts (NOBS)***

- TU Delft - Monomaran Hull
- Det Norske Veritas (formerly DNV) – Volume Cargo Ship
- Daewoo Shipbuilding & Marine Engineering (DSME) – Solid Ballast Ship
- Ballast free ship concept (SNAME, 2004)

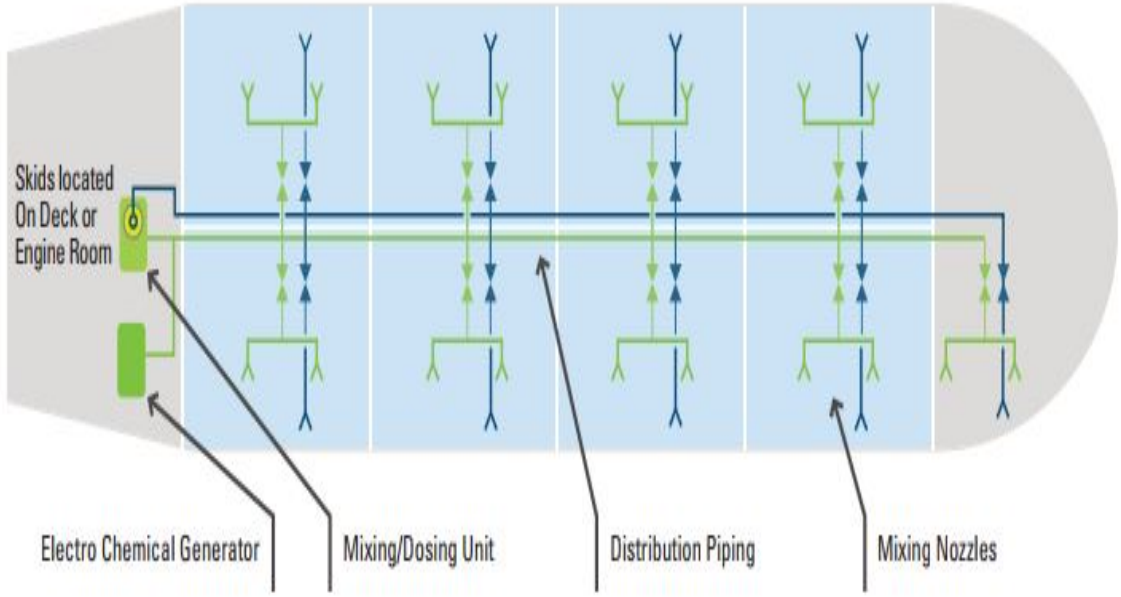
Innovative BWMS

- DAMEN InvaSave, BWC Containers, Envirocleanse inTank system






DAMEN
InvaSave 300
Mobile Ballast Water Discharge Technology


Skids located
On Deck or
Engine Room
Electro Chemical Generator
Mixing/Dosing Unit
Distribution Piping
Mixing Nozzles

Factors for the selection & installation

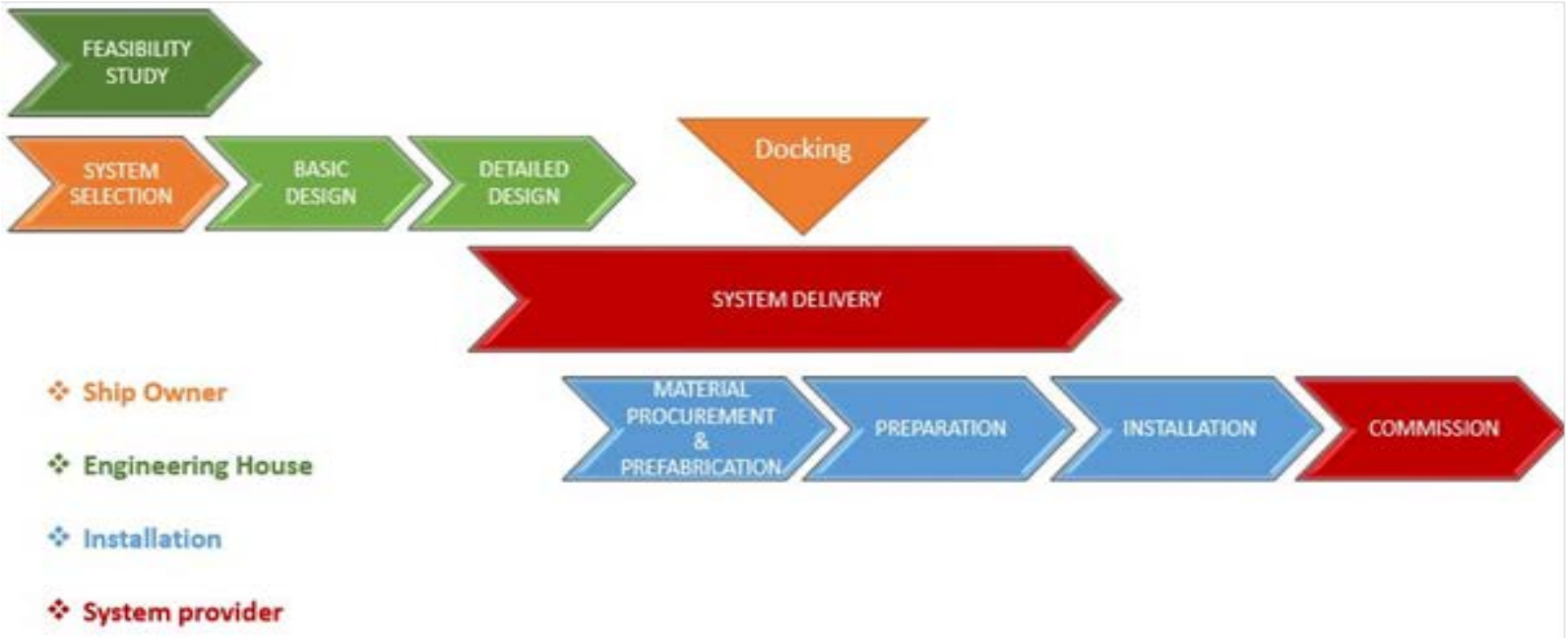
- Necessity for the BWTS
- Vessel's trading pattern
- Type approval
- Status of type approval
- Limited operating conditions
- System design limitations
- Details of type approval certificate
- Contingency measures
- Treatment capacity
- Treatment mode
- Ship specific factors
- Hazards
- Service network
- Simplicity of the system
- Sampling arrangement
- Verification of biological efficacy
- Additional factors

Ref: International Chamber of Shipping

7. SEDIMENTS MANAGEMENT

- Article 5 of IMO's BWMC + Technical Guidelines G1
- Removal and disposal of sediments: at sea or ports/shipyard reception facilities or stored onboard vessels
- Must be removed (ballast tanks) before installing the ballast water treatment system

8. RETROFITTING SHIP



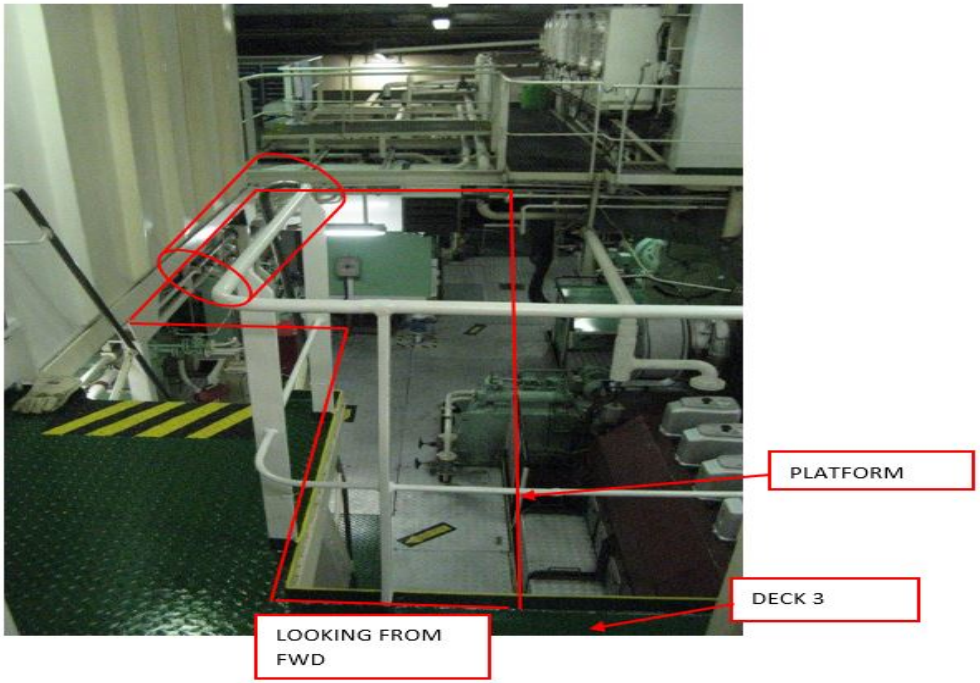
Source: U.M. Blom, The Maritime Group, Presentation for 16th BWMC, Antwerp, 2016

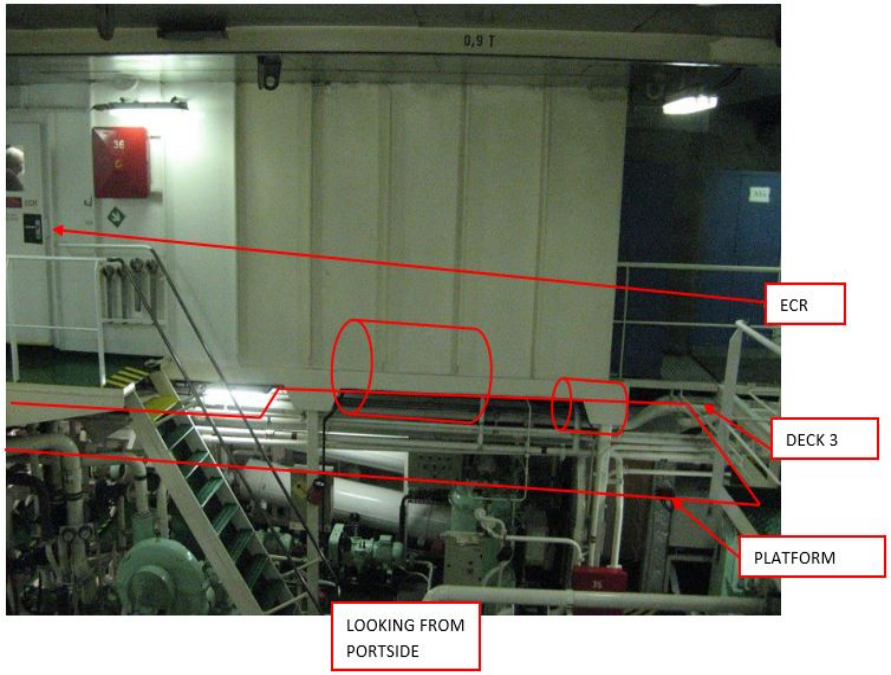
Ship Particulars

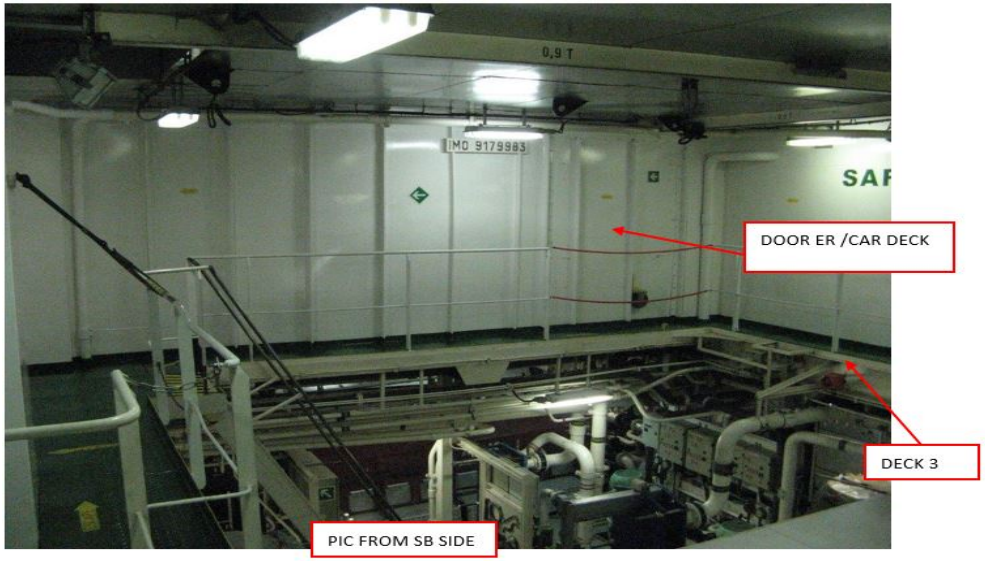
Description	Particulars
Vessel Name	M.V.Main Highway
Type	Vehicles Carrier
Flag	Cyprus
Owner/Manager	Stargate Ship Management GmbH
Scheduled Dry-docking Yard	MSR Gryfia, Szczecin
Design for BWTS Installation	Westcon Design Poland
Length Overall	100 m
Breadth	20 m
Year Built	1998
GT	9233
DWT	3347
Bilge, Ballast & Fire Pumps (2 No.'s)	200/130 m^3/h – 4.3/5.2 bar
Stripping Bilge, Ballast & Fire Pump (1 No.), Piston type	50 m^3/h – 6.0 bar

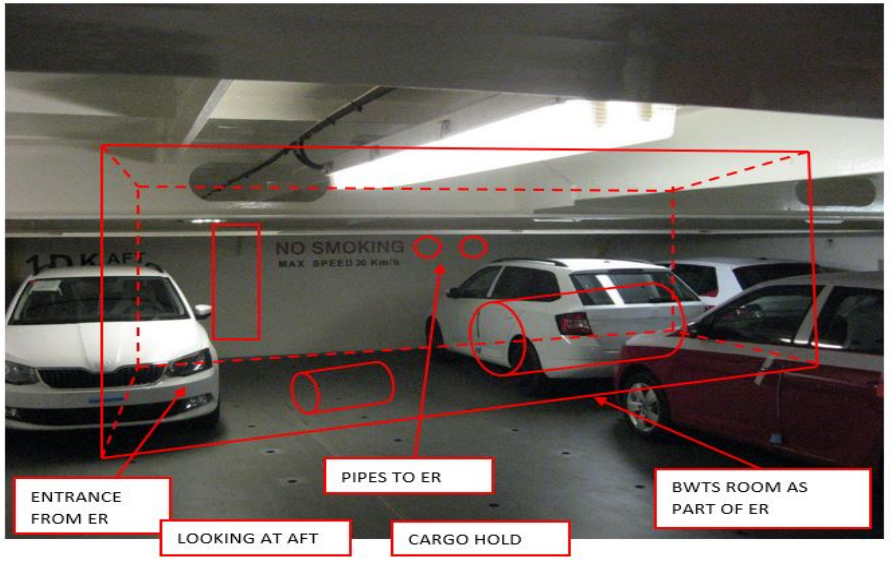
Price of selected systems

S. No.	Systems selected by ship owner	Price (Euros)
1.	GEA, BallastMaster ultraV 250, Germany	120600
2.	TROJAN MARINEX, BallastMaster marineX 250, Canada (Partner in Europe-GEA)	103800
3.	WARTSILA, Aquarius UV 250, Finland	87000
4.	PANASIA, GloEn-Patrol P250, Korea	152900

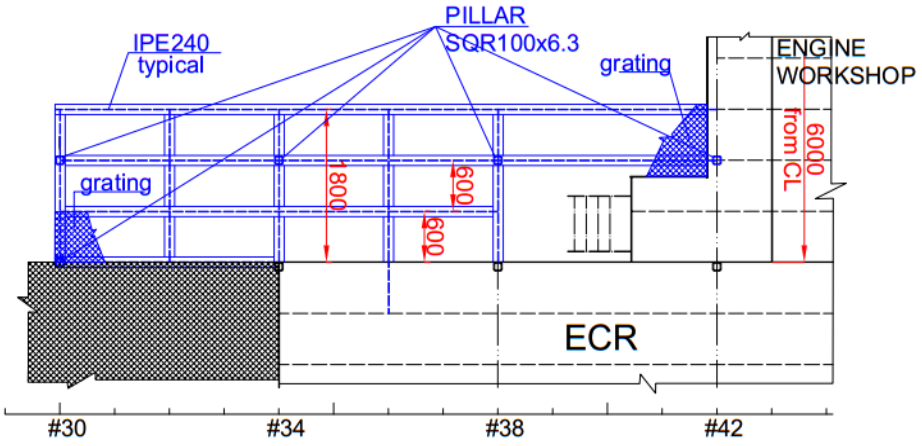

PLATFORM
DECK 3
LOOKING FROM FWD

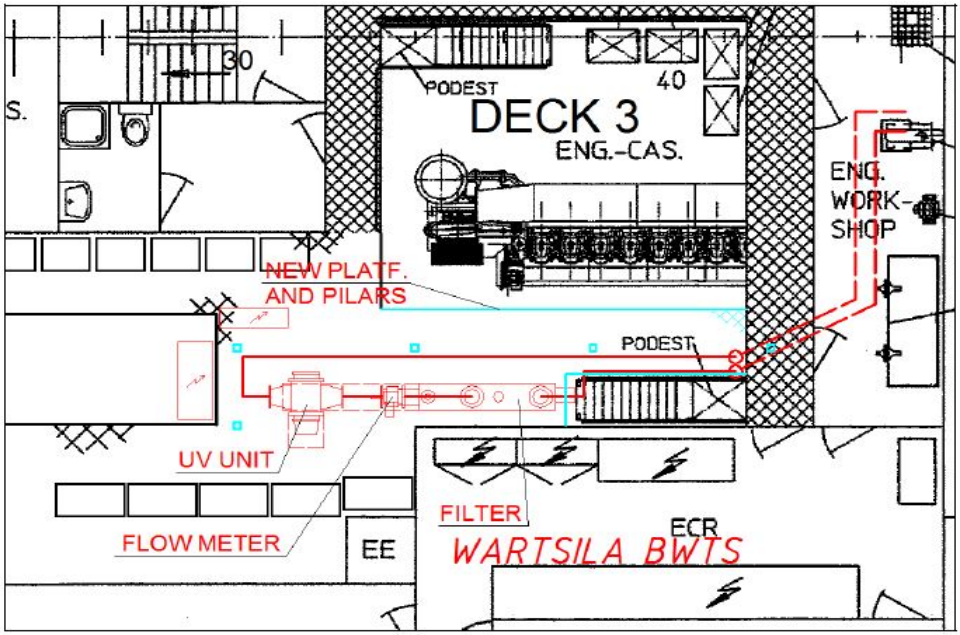

ECR
DECK 3
PLATFORM
LOOKING FROM PORTSIDE


DOOR ER /CAR DECK
DECK 3
PIC FROM SB SIDE

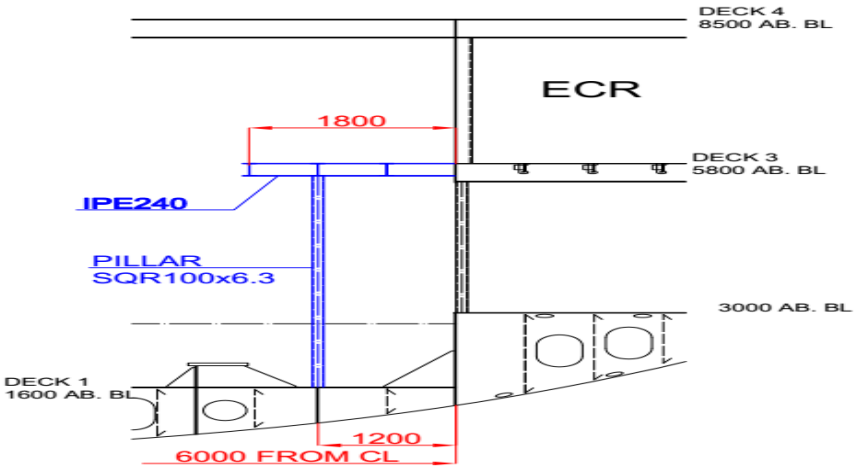

NO SMOKING
ENTRANCE FROM ER
PIPES TO ER
BWTS ROOM AS PART OF ER
LOOKING AT AFT
CARGO HOLD

SECTION 6000 FROM CL SB

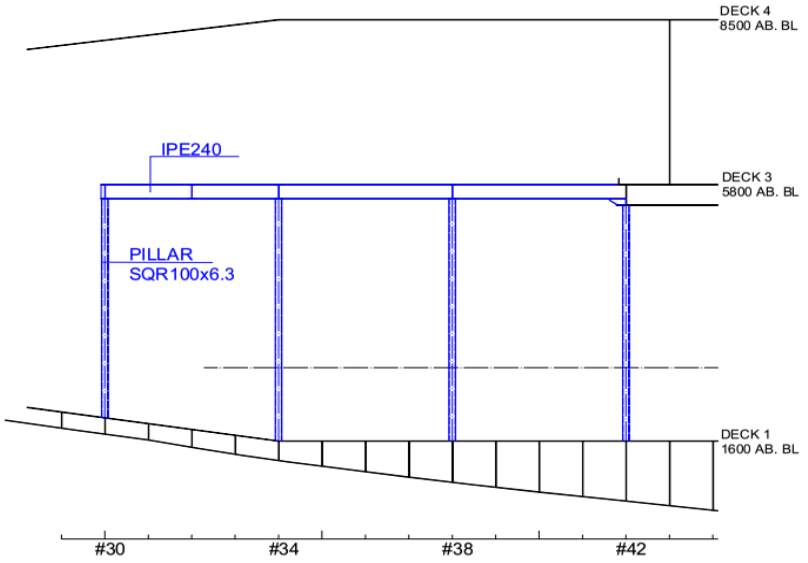


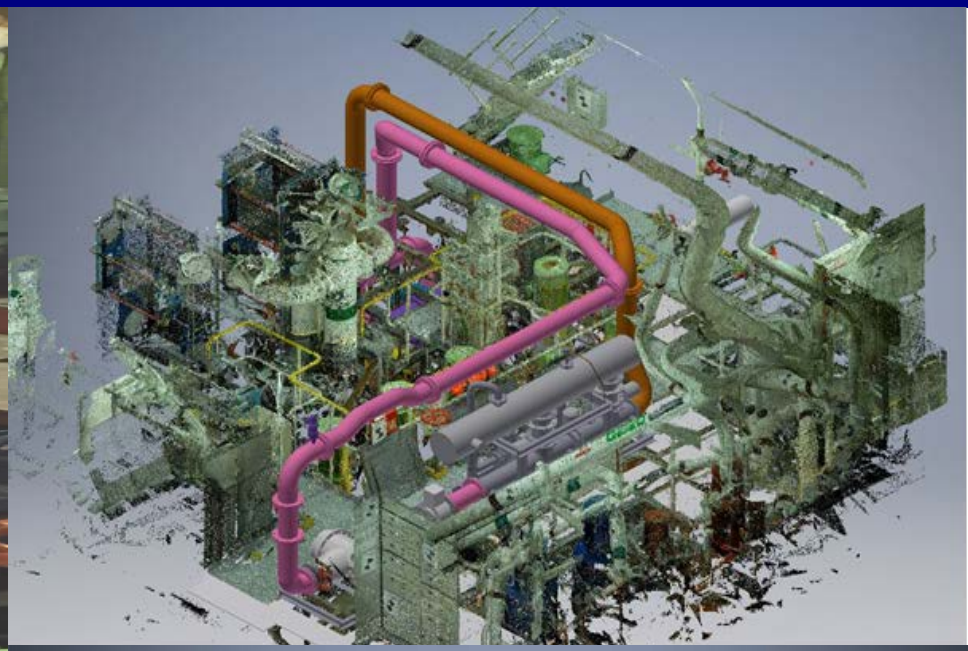


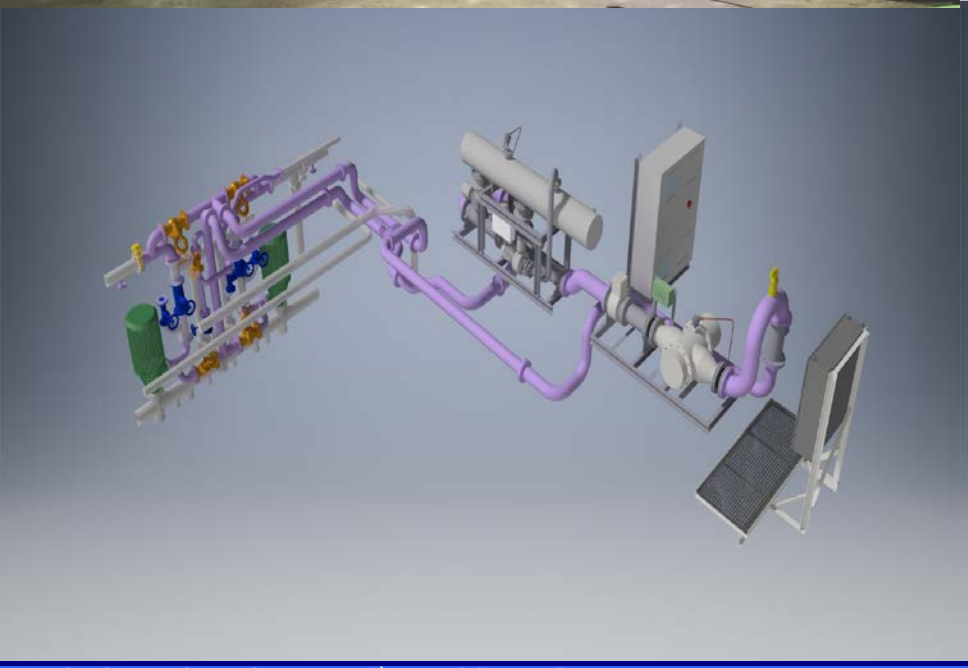
FRAME 38 SB

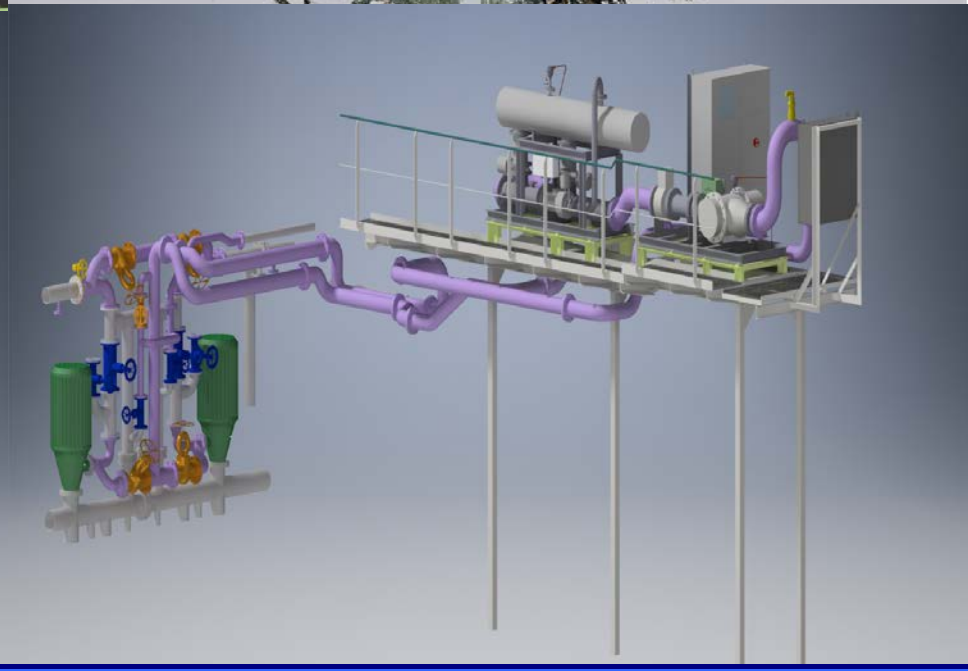


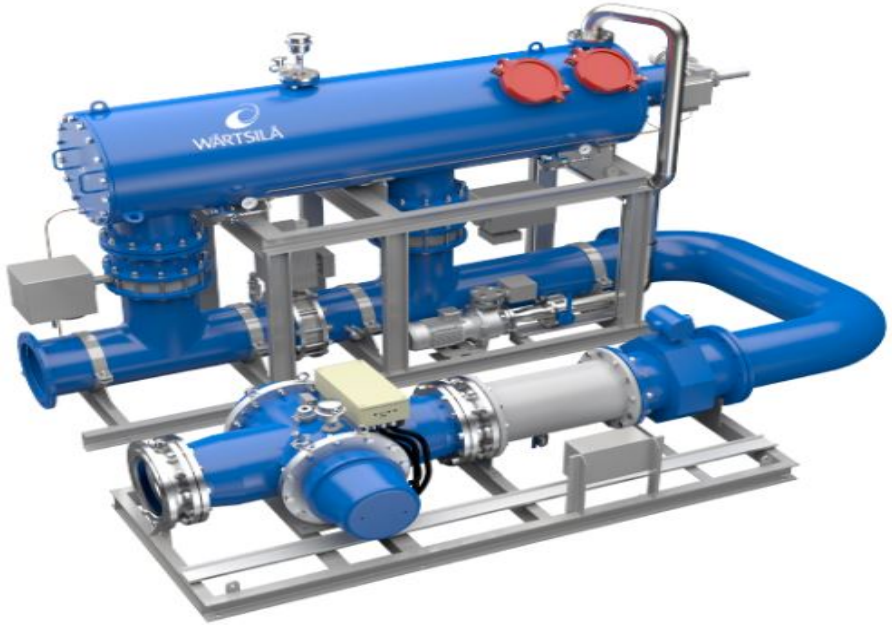
SECTION 4800 FROM CL SB

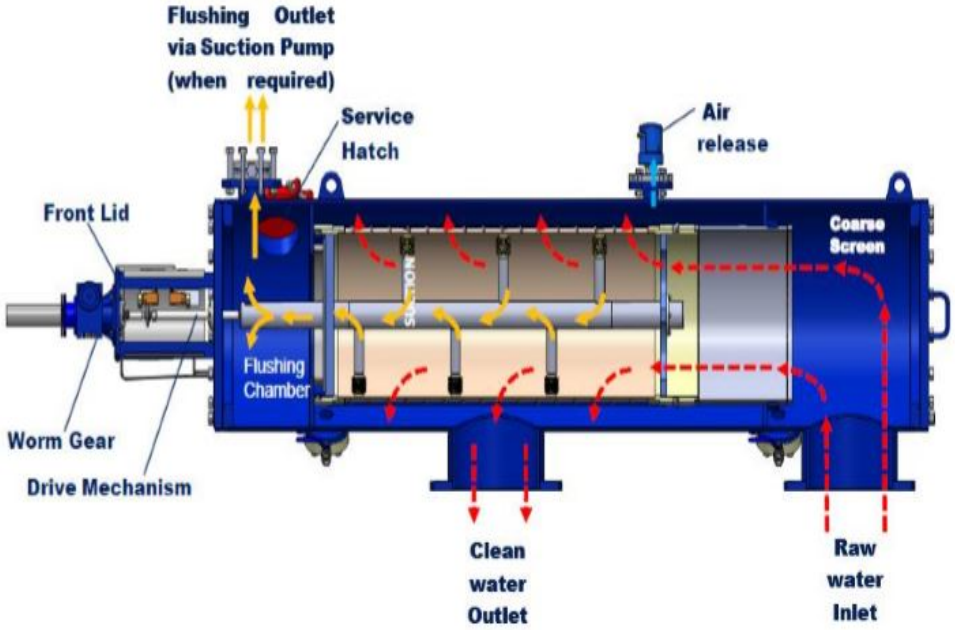









WÄRTSILÄ


Flushing Outlet
via Suction Pump
(when required)
Service
Hatch
Air
release
Front Lid
Coarse
Screen
SUCTION
Flushing
Chamber
Worm Gear
Drive Mechanism
Clean
water
Outlet
Raw
water
Inlet


WÄRTSILÄ

Timeline for turnkey project

Description	Timeline	Responsible Party
Ship Owner Enquiry/Survey of the Vessel/3D Scanning	2-4 weeks	Ship Owner/Design Office
Feasibility Study/Preliminary Design (Concept Design)	1-2 weeks	Design Office
System Selection/Liason with BWTS Manufacturer	1-2 weeks	Ship Owner/Design Office
3D Modeling/Class Approval of Documents	4-8 Weeks	Design Office/Ship Owner
Workshop Documentation	1-2 weeks	Design Office
Selection of Shipyard	1-2 weeks	Ship Owner
Material Purchase	1-2 weeks	Shipyard
Pre-fabrication	2-3 weeks	Shipyard
Installation	2-3 weeks	Shipyard
Commissioning/Trials	1-2 weeks	Shipyard/Ship Owner
Total time required	16-30 weeks (4-7 Months)	

9. BALLAST WATER COMPLIANCE MONITORING

- IMO Port State Control Inspection
  - Initial inspection
  - Detailed inspection
  - Indicative analysis
  - Detailed analysis

- USCG Inspection – AMS, Documents (USCG & EPA/VGP), Contingency measures

Monitoring test kit

- Chelsea Technologies Group: FastBallast (Saudi Aramco ports)

- Aqua tools (SGS & LuminUltra): B-AQUA kit

  - Bioluminescence, ATP-Adenosine Tri-Phosphate

10. CONCLUSIONS

- Alignment of USCG regulations with IMO regulations, Acceptance of MPN method & reduction in approval time by USCG will benefit many treatment system manufacturers.

- Ship owners should not encourage early IOPP renewal survey (de-coupling), undertaking the installation process as early as possible will bring more indirect benefits for the ship owners such as no penalties for non-compliance, creating better image for their clients and raise in the value of the vessel.

- There is no single system which can be an ideal option for all kind of vessels, so the ship owners must pay particular attention to various limitations and their effect on the treatment system while operating in different types of water.

- Retrofitting experience - timeline for turnkey project, it is important to select treatment systems which doesn't cause major change to the existing arrangement of ship.

11. RECOMMENDATIONS

- **Ship Owners -** Earlier feasibility study, Tankers in service + Ex-scanning + Dry-docking
- **Classification Societies & Ship Owners** - Discourage de-coupling of IOPP survey, Small investment (start) + Very economical (end), Installation Cost + Deadline
- **Treatment System Manufacturers -** Partnership + Turnkey + After-sales service

12. FUTURE PROSPECTS

- **FEA:** Additional structures + Ensure strength and integrity of the installation
- **CFD:** Chemical + ballast water mixing in pipes, Pipe specs + homogeneous mixing
- **Sediments:** Deadweight Capacity, Restriction of water flow, Higher fuel consumption
- **Multi-objective Optimization:** System selection + Tool development

Thank you!

http://www.wildoceanfilm.com/marketing/images/photos/marinelife/Big%20Ship.jpg