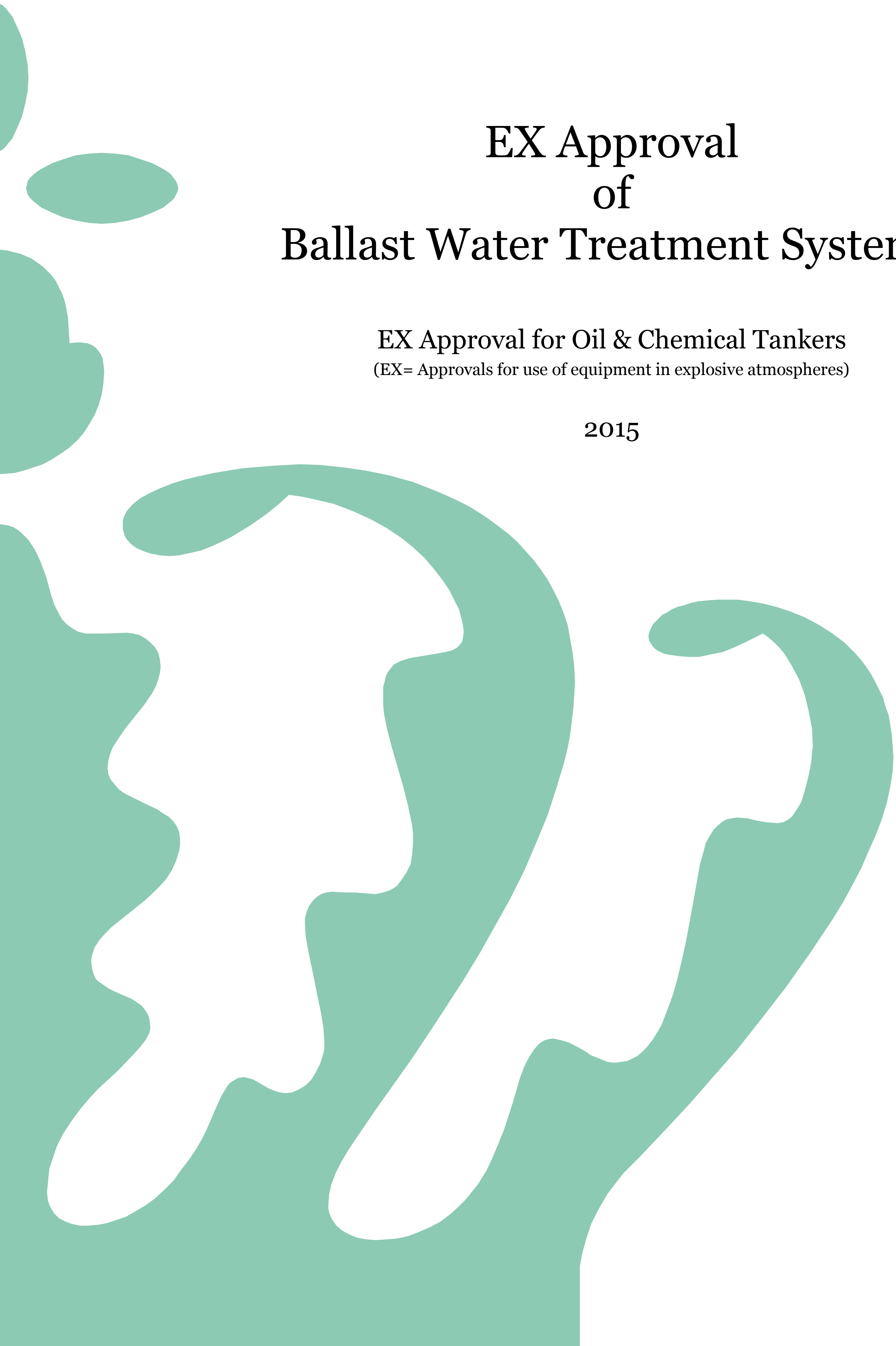
Danish Ministry of the Environment
Nature Agency

EX Approval
of
Ballast Water Treatment Systems

EX Approval for Oil & Chemical Tankers

(EX= Approvals for use of equipment in explosive atmospheres)

2015



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EX Approval of Ballast Water Treatment System

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Contents

Preface

The project "***EX Approval of Ballast Water Treatment Systems***" was carried out from 01.12. 2013 to 31.03.2015 as part of the new regulations concerning ballast water stored on vessels.

This report describes the process and results from the project, including a case study concerning the installation of a Ballast Water Treatment System on an Oil & Chemical Tanker.

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Synopsis

This project concerns Ballast Water Treatment System [BWTS] retrofit installations on Oil & Chemical Tankers for accommodating the pending BWTS requirements established by the International Maritime Organization [IMO]. The largest constraints for such installations are typically available space and high level EX requirements. The project includes a case study concerning installation and Class approval for installation of an ERMA FIRST BWTS on a vessel named Boringia Swan, being a vessel in the aforementioned Class. The project uncovered the process of obtaining the necessary approvals in order to accommodate is BWTS retrofit installation which can be used as foundation for similar retrofit installations in the future.

Resumé

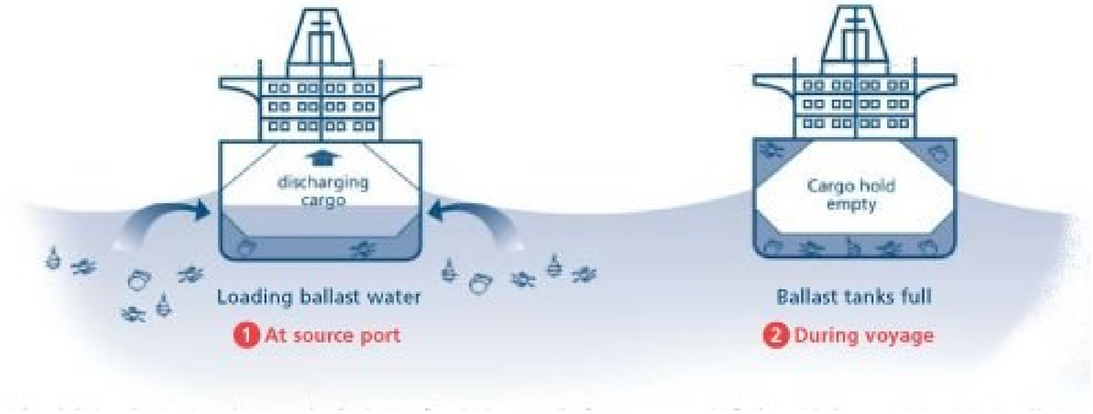
Dette projekt omhandler retrofit installationer af ballastvandsbehandlingsanlæg på olie og kemikalietankere for at kunne imødekomme de nærtforestående ballastvandsbehandlingskrav etableret af International Maritime Organization. De største begrænsninger for sådanne installationer er typisk begrænset plads ombord på skibende samt høje EX krav. Projektet inkluderer et studie som omhandler installation og klasse godkendelse for en installation af et ballastvandsbehandlingsanlæg fra leverandøren ERMA FIRST på skibet Boringia Swan som er et skib i den tidligere nævnte klasse. Projektet afdækker processen bag at opnå de nødvendige godkendelser som er nødvendige for at kunne en retrofit installation af et ballastvandsbehandlingsanlæg. Projektet kan derfor anvendes som grundlag for lignende retrofit installationer i fremtiden.

1. Introduction

1.1 Background

The transportation of cargo on Oil & Chemical Tankers requires ballast water to be loaded or discharged in order to counterbalance the vessel when landing and unloading cargo. This process is illustrated in the Picture No 1 and No 2.

When the vessel is unloading the cargo, the vessel is simultaneously being loaded with ballast water to keep the weight and center of gravity constant. This can be seen in the Picture No 1.



Picture 1: Loading Ballast Water (From GloBallast)

The reverse happens when cargo is being loaded onto the vessel, which can be seen in the Picture No 2. Doing this process, the ballast water is being discharged back into the ocean to keep a constant weight on the vessel at all time.

Picture 2: Discharging Ballast Water (From GloBallast)

When using ballast water to counterbalance a vessel's weight, there is a risk of loading different organism up from the ocean when pumping water into the ballast tanks. This is not a problem if the water is discharged back into the same ocean, but if the ballast water is being discharged in another ocean, there is a risk of contaminating the dumpsite by transferring organism from one ocean to the next.

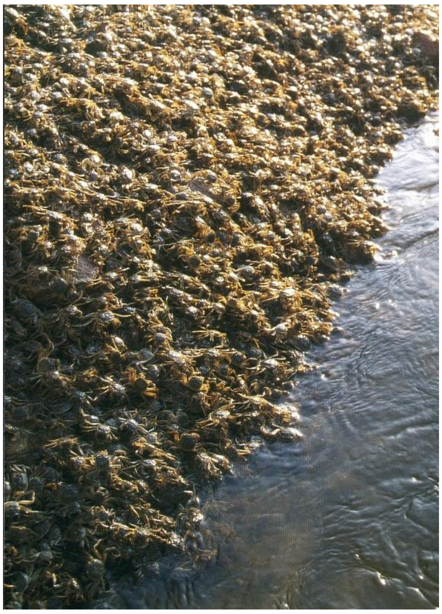
The movement of ballast water from one ocean to another, is one of the four greatest threats to the world's oceans and biodiversity. An example and result of transferring invasive marine species between oceans can be seen on Picutre Nos 3 and 4. (GEF/UNDP/IMO, 2014).

Due to this, the International Maritime Organization (IMO) made a convention in 2004 concerning cleaning of ballast water, which will have an impact on approximately 60.000 vessels worldwide (Shipowners, 2013) (Naturstyrelsen, u.d.).

The convention is expected to come into force 12 months after it has been approved by at least 30 countries, which represents 35 % of the world's merchant vessel tonnage.

There is still several nations, which have not approved the convention, because some of the rules are uncertain and difficult to enforce.

As of now, 44 nations has approved the convention, but some of them has reservations toward the convention.


Picture 3: Invasive marine craps

Denmark is for example allowing vessels to choose between D-1 and D-2 as methods of treatment during the instruction phase. D-1 is ballast water exchange (95% volumetric exchange) or pumping through three time the volume of each tank. D-2 is approved Ballast Water Treatment Systems with not more than 10 viable organisms per $m^3 \geq 50$ micrometres in minimum dimensions and not more than 10 viable organisms per millilitre $<$ 50 micrometres in minimum dimensions and $\geq$ 10 micrometres in minimum dimensions (ABS, 2015). Moreover, if the ballast water is dumped onshore, the vessels are released from the conventions regulations.

In connection with IMO's Ballast Water Management Convention a large industry of Ballast Water Treatment System [BWTS] suppliers has emerged with a wide range of different technologies integrated in their systems.

Picture 4: Invasive Species from Discharging of Ballast Water

Development of new BWTS is continuous, but a common characteristic of the available systems in the market is that they include electrical processes such as electrolysis, UV radiation and various support equipment.

When installing a BWTS on Oil & Chemical Tankers, one of the frequent issues is a lack of space for new additional installations. Simultaneously most of the vessels have strict requirements regarding explosive protection of equipment due to their hazardous cargo and many of the developed BWTS available today, has not obtained any non-explosive [EX] approval required in order to be installed in such EX zones on the vessels. Because of this BWTS suppliers have somewhat neglected the niche of vessels with limited space on board and strict EX requirements, accounting for approximately 20.000 vessels worldwide. These vessels, all need a BWTS, which satisfies the potential EX requirements, Class society requirements and/or can be installed in confined spaces.

1.1 Purpose

The purpose of this project is to develop a system for ballast water treatment as a standard unit that can be Class as well as EX approved and installed in confined spaces in order to be utilized on vessels with EX zones.

Point of origin will be taken in an already IMO approved system. The system will be attempted installed on a vessel with defined EX zones and an EX approval of the system will be sought achieved.

1.2 Goal

The goal of this project is to have a system with a general EX approval from the Class and a general Class approval so it can be sold in commercial trade with both approvals and documentation.

Success of this project is achieved by having a complete documented report including installation propositions, drawing material, necessary certificates and approvals.

The goals and success criteria can be seen in Table No 1 below.

Project goal	Success criteria
Develop standard EX approval for the system	Class approval of the concept
Investigate standard concept to different system sizes	Standard series of systems with EX documentation

Table 1: Project Goals

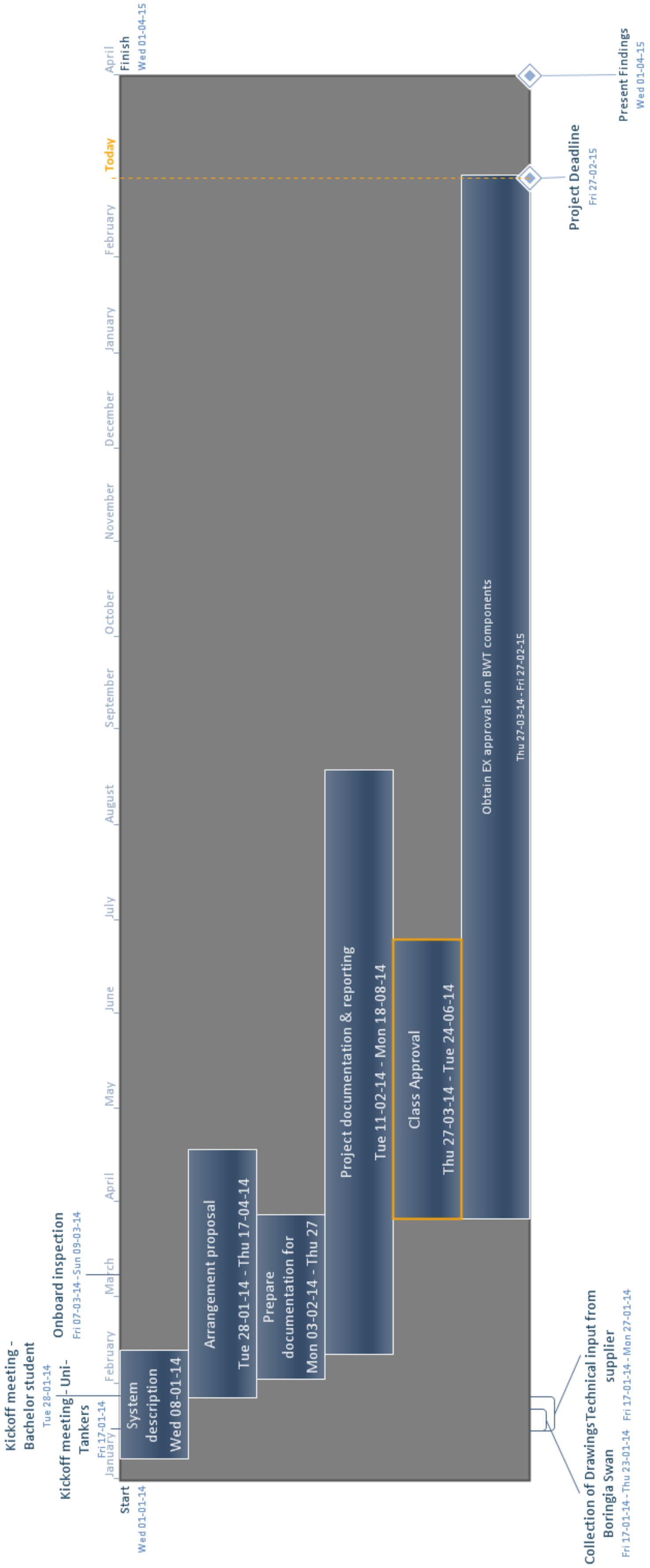
1.3 Execution

To complete this project Vestergaard Marine Service (VMS) and ERMA FIRST has joined forces to develop an Class and EX approved system for vessels in the category of Oil & Chemical Tankers.

VMS is a company, which works with service on rotations equipment, sales of marine parts, engineering and project management. In connection with this project, VMS will be in charge of the planning and execution of the project. Please see Picture No 5 on page 11 and Enclosure No 1 for the project timeline.

ERMA FIRST is a company who already has an IMO approved BWTS for cleaning of ballast water. Their systems uses filtration and electrolysis technology to treat the ballast water. The selection process for the BWTS is given the case study on page 12.

In order to execute this project, the vessel Boringia Swan from Uni-Tankers has been chosen as a case study, which is done to analyse how a BWTS can be installed on Oil & Chemical Tankers. Boringia Swan was selected for this case study as a collaboration with Uni-Tankers was initiated and because the vessel is deemed a good representative for the Oil & Chemical Tanker category of vessels.



Picture 5 – Project Timeline

2. Case Study: Boringia Swan

This case study is based on the Oil & Chemical Tanker named Boringia Swan and will be used as a generalization of the complications which occurs prior to and during the installation of a BWTS on vessels with limited space and EX regulations.

Throughout the case study, the vessel Boringia Swan will briefly be presented and different BWTS technologies will be presented in order to describe the market and the choice of system. Secondly, a general description of the chosen ERMA FIRST system will be described together with an installation specification for the chosen ballast water treatment system.

2.1 Boringia Swan

Uni-Tankers is a Danish company with a number of Oil & Chemical Tankers. One of the vessels in their fleet is Boringia Swan. This vessel sails between various oceans and it is therefore required to install a BWTS to accommodate the future IMO regulations.

Boringia Swan requires a BWTS with a capacity of 300 m^3/h during ballasting and 600 m^3/h during de-ballasting in order not to disturb its original operational pattern when loading and unloading cargo. Boringia Swan's current ballast pump system is comprised of two 300 m^3/h pumps located in the vessel's pump room. The existing pumps are directly connected to their electrical motors, located in the adjacent engine room by breaching the bulkhead. The reason for this setup is that the pump room is classified as a Hazardous area zone 1, where all electricity devices must be kept outside. The zones are classified in accordance to the frequency of the occurrence and duration of an explosive gas atmosphere:

- Zone 0 – An area in which an explosive gas atmosphere is present continuously or for long periods
- Zone 1 – An area in which an explosive gas atmosphere is likely to occur in normal operation
- Zone 2 – An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time

(HSE, 2015)

Boringia Swan is a good representation of the vessel category named Oil & Chemical Tankers, as the ballast pump system setup is common across a dominant part of the vessel category. Also similar to the rest of the vessel category, Boringia Swan's requirements towards installing a BWTS includes no or limited use of cargo space.

On time of choosing, there was various alternatives of BWTS. One of Uni-Tankers challenges was that most of the suppliers of BWTS, has focused on vessels with plentiful space for retrofit installations and with no or limited EX requirements. In order to provide a more generic study this project will thus seek to accommodate an installation that both takes confined space and EX requirements into consideration.

2.2 General Description of Ballast Water Treatment Technologies

A BWTS can be combined of different technologies and today there is more than 40 approved systems and approximately 20, which are waiting for an approval of their system (Maritime, 2013).

In general the different BWTS can be installed either in-line or in-tank. An in-line system can be integrated downstream to the ballast pump in the existing ballast system. Systems are often build up in modules and it is therefore easy to find a solution, which fits on most vessels. An in-tank system requires an expansion of the existing piping arrangement within the ballast tanks. The treatment of ballast water in an in-tank system is performed during sailing and can therefore be used as a regular ballast system.

Basically, there is three fundamental ballast water treatment technologies, which are generally combined within one system. These are mechanical, physical and chemical. These can be seen in table No 2 on the following page.

Mechanical	Chemical	Physical
1. Cyclonic Separation (hydroclone) 2. Filtration	1. Electro-chlorination 2. Electro-Catalytic 3. Advanced oxidation 4. Chemical injection (Chlorine, Chlorine dioxide, Peraclean) 1. 5. Ozonation ocean	1. Coagulation 2. Ultrasound 3. Ultraviolet 4. Heat 5. Cavitation 6. Deoxygenation (Inert Gas Injection)

Table 2: Ballast Water Treatment Technologies

2.2.1 Mechanical

The mechanical technologies consists of filtration or cyclonic separation.

Filtration is used to remove organism and sediments with a size of 40 to 200 µm by filtrating the water. The filtration process uses discs, basket or candle filters with automatic backwashing.

Cyclonic separation also known as hydroclones is a centrifugal separation. This process can remove all organism and sediments, which are larger than 20 µm. The hydroclones separate the particles through high-velocity centrifugal rotation of the water (Maritime, 2013).

2.2.2 Physical

The physical technologies consists among others of coagulation/flocculation, ultrasound, ultraviolet, heat, deoxygeneration.

Coagulation treats ballast water by adding a coagulant and magnetic powder in coagulation and flocculation tanks. Agitation of the water causes plankton, viruses and mud to coagulate into 1 mm wide magnetic flocs. These can then be collected with magnetic discs in a magnetic separator (Maritime, 2013).

Ultrasound is generated by a transducer, which converts the mechanical or electrical energy into high-frequency vibration.
The effect of ultrasound treatment is based on physical and chemical changes resulted from cavitation (Martob).

When ultraviolet light is used, amalgam lamps surrounded by quartz sleeves produce UV light, which changes the molecular structure of the organism and thereby prevents it from reproducing.
If heat is used to treat the water, the water can also be used to provide engine cooling while being disinfected (Maritime, 2013).

The deoygeneration method relies on reducing the pressure of oxygen in the space above the water by injecting an inert gas or inducing a vacuum. The removal of oxygen may also lead to a reduction in corrosion (Maritime, 2013).

2.2.3 Chemical

The chemical technologies consists among others of electro-chlorination, electro-catalysis, advanced oxidation, ozonation and last but not least chemical addition such as sodium hypochlorite, chloride dioxide and hydrogen peroxide.

Electro-chlorination/electrolysis uses electrolytic cells to generate a sodium hypochlorite (bleach) solution from the ballast water's salinity and electricity (Schulz, 2014).

Electro-catalysis is producing with the use of special anodes apart from free chlorine hydroxyl radicals

Advanced oxidation creates a radical with the help of a catalyst and a light source. These radicals then destroy the cell membrane of microorganisms. The radicals, which never leave the unit, have a lifetime of only a few milliseconds and pose no risk to the environment or crew (Laval, 2014).

Ozone has been widely utilized in onshore applications such as water disinfection, aquaculture and power plants cooling systems. Ozone must be generated onsite since it is unstable in atmospheric pressure. Ozone gas is bubbled through the water and is effective when killing microorganisms (Martob).

Chlorination is a treatment, which adds chlorine to the water in order to destroy the cell walls of organisms (Maritime, 2013).

Chloride dioxide is a purification treatment where a small amount of supply water flows through a venture injector creating a vacuum that draws the purate and acid into a mixing chamber. When these chemicals are combined, they form a dilute aqueous CIO_2 solution, which is added to the water (Maritime, 2013).

A BWTS consists of one or more of the above-mentioned technologies. For this study, ERMA FIRST's system has been chosen, which consists of both filtration and electro-chlorination which was found as a good combination of technologies with a greater opportunities of further development Additionally ERMA FIRST's 300m^3/hour BWTS could accommodate the vessels requirement without disturbing its operational pattern. In the section below ERMA FIRST' BWTS is presented in detailed.

2.3 ERMA FIRST's Ballast Water Treatment System

ERMA FIRST has developed a BWTS, which consists of a 200 microns pre-filer, multiple Hydroclones, and a full flow electrolytic cell.

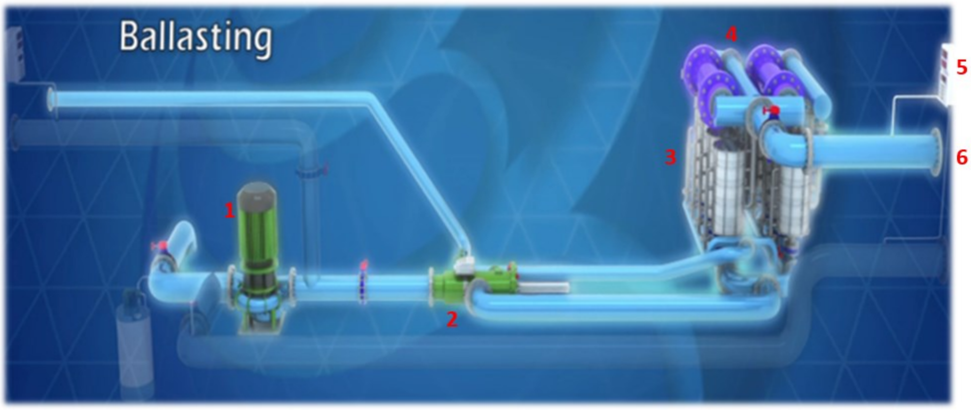
This system consists of two different operational modes, one for ballasting and one for de-ballasting of ballast water.

ERMA FIRST systems vary in sizes and capacities. The chosen system for the Boringia Swan has a capacity of 300 m^3/h with its skid mounted design has the dimensions 2900 x 3000 x 1200 cm. These dimensions makes it impossible to install the system as a retrofit in this case study as the pump room on Boringia Swan only has a width of 1325 cm. It is, however, possible to dismantle the system, install the systems' separate components, and connect it to the existing ballast pumps.

2.3.1 Ballasting Mode

When ballast water is loaded, there is used a pump, a pre-filter module, hydroclones, electrolysis cells, chlorine sensors and ballast water tanks to for the treatment process. Sediments and coarse material returns to the sea via a drain line.

This system is illustrated in Picture No 6 on the following page and a description of each part can be found beneath the picture.



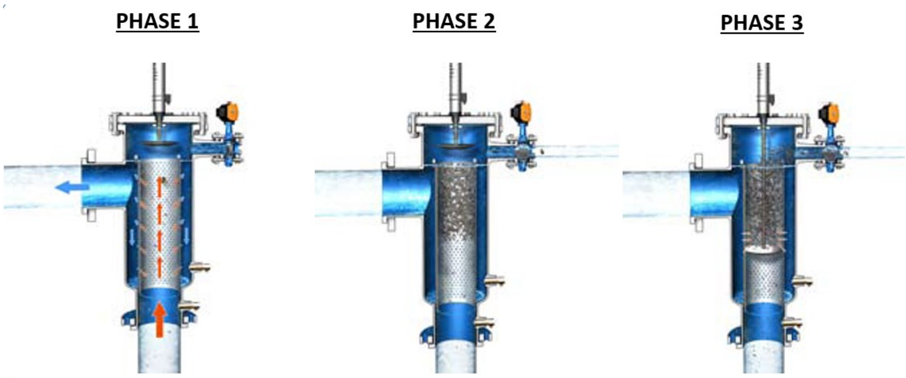
Picture 6: ERMA FIRST ballasting system (From ERMA FIRST)

No 1: Ballast Water Pump
The ballast water pump is used when loading ballast water from the ocean and into the BWTS.

No 2: Pre-filter module
The pre-filter module is used in order to remove all organic and inorganic particles which are bigger than >200μm, see enclosure No 3.

During the cleaning process, a local vacuum effect, also known as the Bernoulli principle, which is created to promote the removal of the accumulated debris, which is discharged overboard through the drain piping.

The rapid reduction in diameter creates an increase in velocity and a rapid pressure drop which forces filtered particles to the inside of the basket to detach from basket's surface, which can be seen in picture 7.



Picture 7: Pre-filter Cleaning Phases (From ERMA FIRST)

No 3: Hydroclones
Innovative Hydrocyclones are used for the separation of particles and microorganisms, which are bigger than >20microns with a maximum separation capacity of 120m³/hour each, see Enclosure No 4.

As the water passes from the cyclones, centrifugal forces enable separation of particles bigger than >20microns while the water pressure efficiently drains the removed particles overboard.

Fluid and particles that enter tangentially into the hydroclone starts to rotate and a centrifugal radial force is generated towards the outside.

Particles with a density larger than the water experience an effective force towards outside and the particles will thereby leave via the lower drain exit whereas a cleaned flow leaves via the overflow tube at the top side.

No 4: Electrolysis Cells

The ballast water is then transported from the Hydroclones to the electrolytic cell. Here, full flow advanced electrolysis is used for the production of Sodium Hypochlorite at a max concentration of 10mg/Litre to disinfect the remaining organisms in the ballast water during its time in the ballast tanks. The electrolytic cell produces the sodium hypochlorite by applying low voltage through the electrodes. The electrolytic cells is comprised of specially coated titanium electrodes. It is governed and production levels regulated in accordance to information obtained from the systems chlorine sensors and flow rate monitor as it depends on the ballast water's salinity content and the flow rate of the BWTS.

No 5: Chlorine Sensor 1

A chlorine sensor located downstream of the cells, monitors the chlorine concentration which depends on flow rate and salinity levels.

No 6: Ballast Water Tanks

Ballast water tanks are used to store the water in connection to the counterbalance of the vessels weight, when the cargo is un-loaded.

2.3.2 De-Ballasting Mode

Picture 8: ERMA FIRST de-ballasting system (From ERMA FIRST)

No 7: Ballast Water Tanks

When cargo is being loaded onto the vessels, the ballast water tanks are being emptied and ballast water flows through the system before it is being discharged into the sea.

No 8: Chlorine Sensor 1

When the ballast water is being pumped through the system chlorine sensor 1 measures the chlorine level when entering and leaving the tanks.

No 9: Neutralization Panel

The purpose of the dosing pump is to add the neutralizing agent, sodium bisulfite to the treated ballast water during the de-ballasting mode to neutralize the potentially remaining chlorine level of the ballast water. The neutralization panel utilize the monitored flowrate and the two chlorine sensors to regulate the amount of sodium bisulfite that needs to be applied.

No 10: Ballast Water Pump
The ballast water pump is used to transport the ballast in the system during both ballasting and de-ballasting.

No 11: Chlorine Sensor 2
Chlorine Sensor 2 is used to measure the chlorine level in the ballast water before it is discharged into the ocean.

2.4 Solution Development

With the BWTS and the case study's vessel presented, this section seeks to document how solution development has been approached during the project. As mentioned this study will seek a solution that both takes confined space and EX requirements into consideration. In general, two dominant options would be possible, being installation of a BWTS in the pump room or a deckhouse. Installing a deckhouse would allow for a solution where the entire deckhouse could be generated as an independent area with no EX requirements or with an EX approved BWTS within. A negative result of having the BWTS in a deckhouse would be that ballast water must be lifted significantly higher than the pump room, increasing amount of energy required by the ballast pumps for operation. On the contrary an installation within the pump room would ensure a more generic study that took both the confined space dilemma and EX requirements into consideration. After analysis and discussions between VMS, Uni-Tankers and ERMA FIRST it was selected that, the case study should focus on an installation within the pump room which is a very narrow EX zone with a width of merely 1325 mm. Hereafter a dialogue was initiated with the Classification society of the vessel, in this case being DNV.

The space requirements for an ERMA FIRST' BWTS with a capacity of 300 m^3 and with limited EX approved components, it was not found possible to simply install it as a single unit other places than on Boringia Swan's deck in an EX proof deckhouse. Such a solution is disliked by most chief officers and crews, which the project group continued to focus on utilizing available space in respectively the pump for EX approved components and secondly components without EX certificated in engine room by breaching the bulkhead between the two.

As previously presented Boringia Swan's pump room is not designed for installing new additional systems and with its narrow width of merely of 1325 mm, installing any BWTS as a single unit would be an impossible task, see Picture No 9 below.

Picture 9: Limited available space in pump room (From Boringia Swan)

Analysing ERMA FIRST's BWTS, it became clear that the individual components could be installed at separate locations connected with piping and sensors as in the original setup of the BWTS unit. This allowed for installation in confined spaces such as the pump room.

Secondly, uncovering the supply network used for the manufacture of individual components utilized in the BWTS, it was possible to obtain these with EX certificates allowing installation in the pump room, see Enclosure No 7.

For the electrolytic cell it was not possible to acquire an EX certificate, at the time of analyses as the component relies on applying electricity directly through the ballast water, please confer Section 2.2.1 Ballasting Mode on page 13. Thus, it required to be installed outside any EX zone. Looking at the General Arrangement drawing on Boringia Swan it was concluded that a potential solution towards this was to install the electrolytic cell in the engine room adjacent to the pump room by breaching the bulkhead with DN250 piping going to and from the electrolytic cell, similar to the current setup of the vessel's current two ballast pumps.

The Class dictates that it is not allowed to pump ballast water from tanks adjacent to cargo tanks carrying liquid chemicals or oils with a flash point below 60 degrees Celsius through the engine room, as it is a gas safe area. This requirement from the Class did not prevent the proposed solution as ERMA FIRST's BWTS treats the intake of ballast water and because the existing ballast water system would be utilized during de-ballasting avoiding transfer through the engine room.

With a preliminary proposal for solution development in hand, an inspection on board Boringia Swan was arranged by VMS together with the vessels crew and ERMA FIRST, which took place in Piraeus Greece March 8th, 2014.

The concept of installing the BWTS components individually in the pump room and with the electrolytic cell placed in the engine room was presented to the ship's crew and ERMA FIRST, where after the pump room was inspected in order to determine specific locations for the individual components as well as routing of piping.

Boringia Swan's pump room was comprised on a total of eight smaller compartments with minor spaces available for installation.

The connection points between the existing ballast water system and the new BWTS was identified where after space requirements and location of the BWTS components was discussed and agreed upon. Secondly the engine room was inspected and room available for installation of the electrolytic cells identified.

Installation of the 300m^3/hour ERMA FIRST BWTS includes:

- Installation of BWTS modules: Pre-filter, 3x Cyclonic Filters, Electrolytic Cell with power supply
- Installation of piping with valves to and from existing ballast water system
- Installation of neutralizing system including: Dosing pump, Sodium bisulfide tank, chlorine sensors
- Installation of electrical systems for the BWTS including: Monitors, Remote controlled components, etc.

Below a brief clarification of how the system setup was intended is given. The system's flow diagram is shown in Enclosure No 2.

The BWTS is to be installed in respectively the pump and engine room. Installation of the BWTS have been divided into 7 main parts being:

1. Booster pump
2. BWTS Pre-filter module, with drain piping
3. 3 cyclonic filters, with drain piping
4. Electrolytic cell
5. Additional valves on existing system
6. Neutralization system
7. Control Cabinet

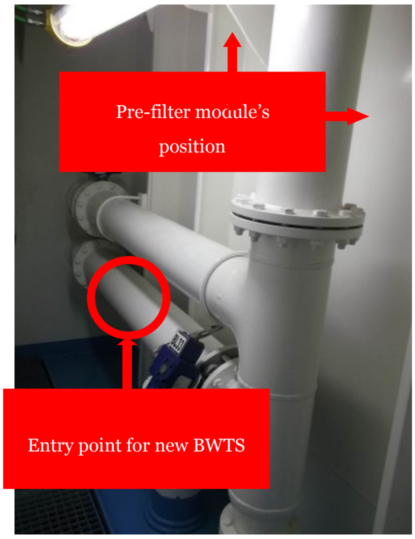
Booster pump

DN150 piping will be connected to the existing ballast pump system as illustrated on Picture No 10 on the following page. This pipe will lead the ballast water to a new additional booster pump and onto the pre-filter component.

BWTS Pre-filter module

The pre-filter module will be positioned on top of the horizontal pipes located in the starboard center pump room, as illustrated on Picture No 10.

A DN40 drainpipe is lead from the pre-filter module up onto the DN100 drain pipe from the cyclonic filters.

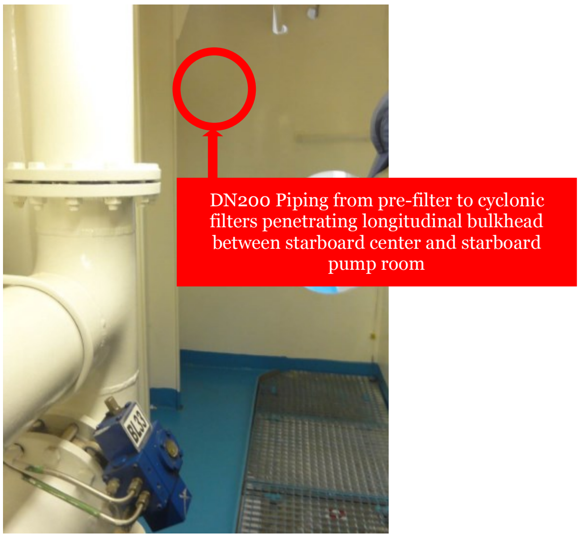


Picture 100: BWTS Entry point and positioning of pre-filter in Upper Starboard Center Pump Room

A control box for the pre-filter is to be installed next to the pre-filter for local control during operation.

3 Cyclonic Separators

A DN200 Piping will be installed from the pre-filter leading ballast water from the starboard center pump room, breaching the longitudinal bulkhead to the starboard pump room. Here the piping will be connected to the three cyclonic separators with which are to be mounted horizontally on a steel fundament, see illustrations of Pictures No 11 and No 12.



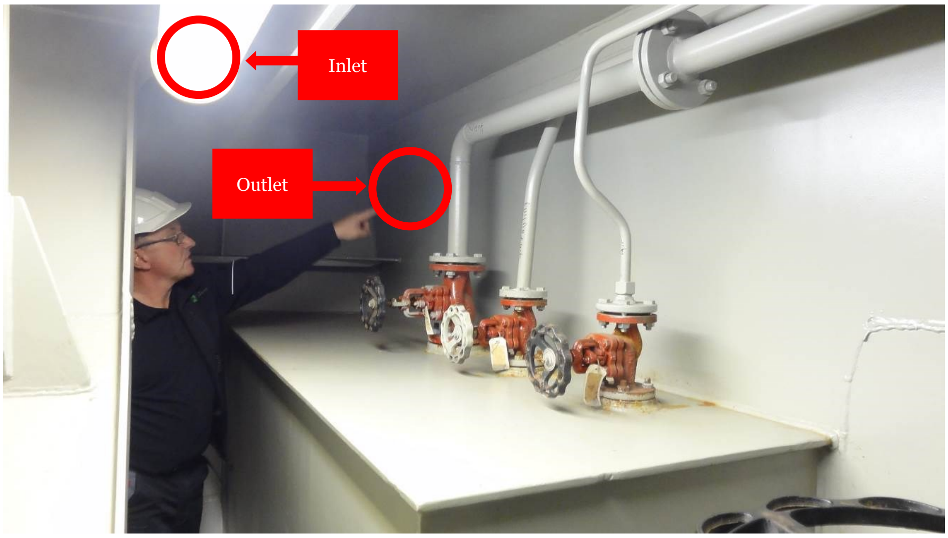
Picture 11: BWTS piping through upper longitudinal bulkhead in Upper Starboard Centre Pump Room

Picture 112: Position of three cyclonic filters in Upper Starboard Pump Room

DN50 drain piping in the steel foundation will be joint to a DN100 piping which will be lead up connecting to respectively the pre-filter drain piping and to existing piping, leading drain water out on starboard side during ballasting.

Outlet DN100 piping from the three cyclonic separators are joined within the steel fundament to DN250 piping which will be lead out into the upper starboard pump room, breaching platform deck to the lower starboard pump room.

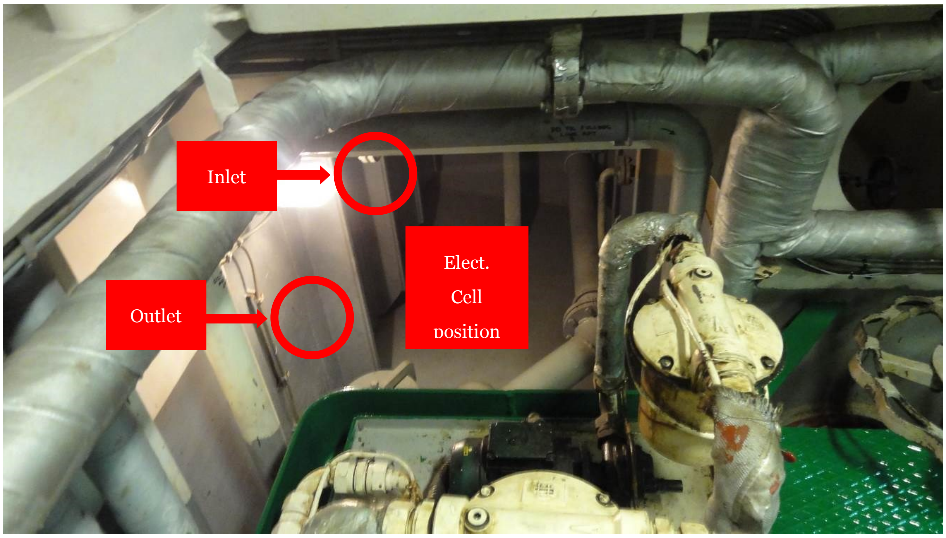
From here the DN250 piping is lead over the starboard sea chest, through the bulkhead and into the engine room as illustrated on Picture No 13 on the following page.



Picture 123: Piping between cyclonic filters and electrolytic cell in Lower Starboard Pump Room

Electrolytic cell

A DN250 piping lead through the bulkhead will be connected to the electrolytic cell positioned in a steel frame on the starboard tank top in the engine room as illustrated on Picture No 14.



Picture 134: Position of electrolytic cell Starboard Tank Top in Engine Room

The power supply for the electrolytic cell will be positioned appropriately in the starboard side of the engine room. From the electrolytic cell, a DN250 outlet pipe is lead to and through the bulkhead into the lower starboard pump room, above the sea chest as illustrated on Picture No 15.

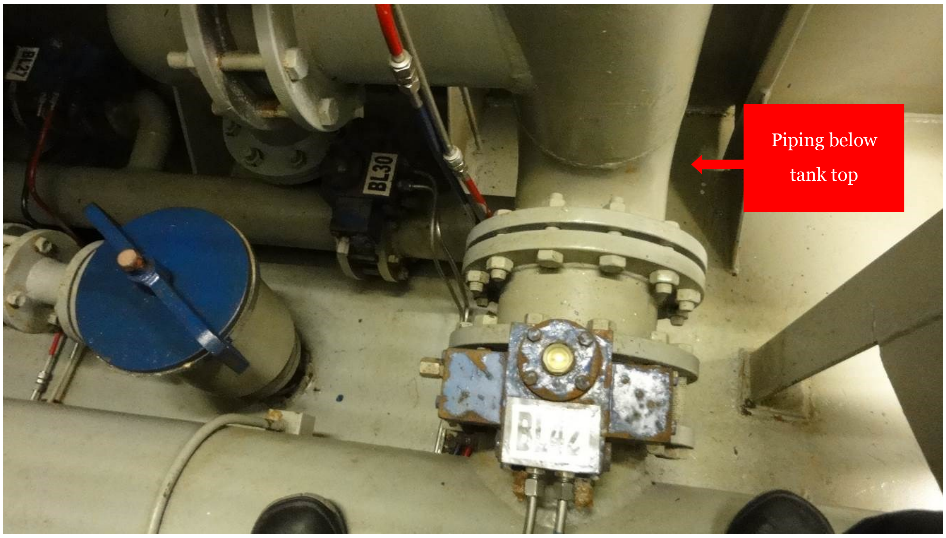
Picture 145: Piping penetrating bulkhead from engine room in Lower Starboard Pump Room

After the bulkhead penetration, DN250 piping is lead down along the piping from the sea chest. Here it is divided into two DN200 piping, which are connected to the existing ballast system.

The electrolytic cell is to be positioned appropriately, preferably in the starboard side of the engine room.

Additional valves on existing system

Two additional valves are to be installed on existing piping in order redirect ballast water to the new BWTS during ballasting.



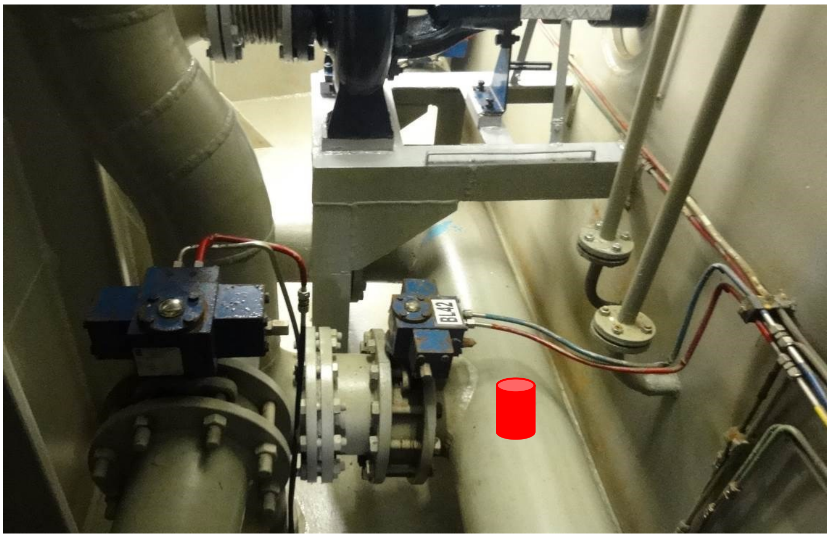
Picture 16: Location of piping for additional valves in Lower Starboard Centre Pump Room

Neutralization system

In order to protect the environment from chlorine contamination during de-ballasting of the treated ballast water, a neutralization panel with dosing pump for sodium bisulfide and chlorine sensors is to be installed. The neutralization panel with the dosing pump and a 100 litres tank for the liquid sodium bisulfite is to be installed next to the existing ballast pump in the lower port centre pump room with 15 DN piping connecting it to both sides of the BL43 on the crossover pipe.

In total four chlorine sensors are to be installed and all chlorine sensors will be connected to the neutralization panel so they can feed it with information of the chlorine content so, it can regulate dosing quantities accordingly.

The positioning of the chlorine sensors next to two valves are shown on Picture No 17 and 18.



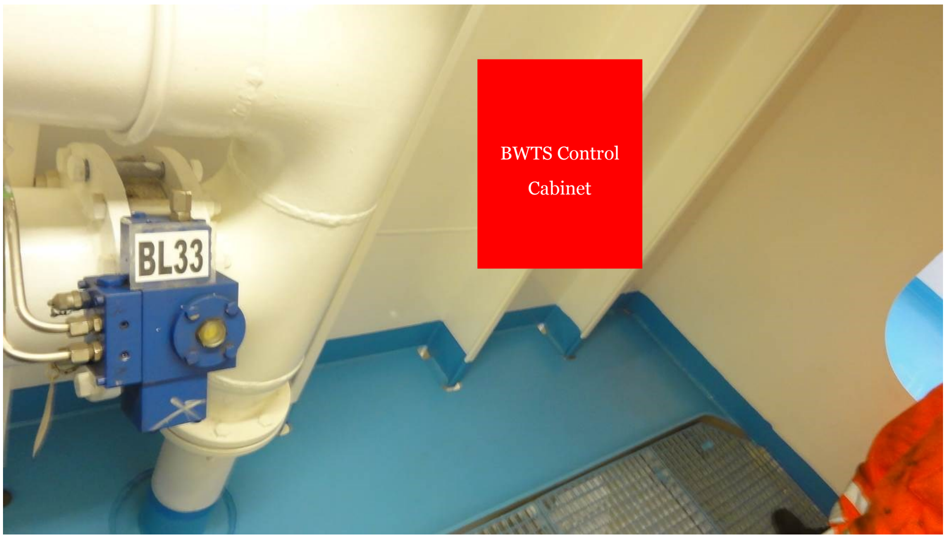
Picture 157: Position of chlorine sensor next to BL42 in Lower Port Centre Pump Room

Picture 168: Position of chlorine sensor next to BL38 in Upper Port Center Pump Room

The neutralization panel will be installed next to the ballast pump in the lower port centre pump room.

Control Cabinet

The control cabinet for the BWTS will be installed in the upper starboard centre pump room as illustrated on Picture No 19 on the following page.



Picture 17: Location of BWTS control cabinet

The BWTS control cabinet will be linked to the Ballast Water Management Panel in the cargo control station.

After the on board inspection, an installation specification was written for installation of a 300m3/hour ERMA FIRST's BWTS installation on board Boringia Swan. Additionally a flow diagram of the BWTS was developed, specifying system entry points, sequence and location of components, see Enclosure No 2. With the solution proposal developed DNV was contacted on March 28th, 2014 with the intent of obtaining a general BWTS approval and general solution assessment. DNV did not allow any breach of the bulkhead between the pump room and engine room. In response the project group analysed the possibility of obtaining the required EX certificate on the electrolytic cell and moving the component into the pump room. At the time of writing, ERMA FIRST obtained the EX certificate for the component which allowed installing the entire BWTS as separate components in the pump room.

The solution development found that a pump room installation would be a feasible option, from a technical point of view, but requires that all BWTS components has obtained EX certificates. Additionally it should be noted that installing a BWTS in an EX approved deckhouse still is regarded as a feasible solution if the space allows it. Finally it is important to know the when conducting projects similar to this, close collaboration with the vessel's respective Class society should be initiated as early as possible, as implementation of BWTS will vary from project to project and from vessel to vessel.

This project should not merely be generalized, but instead used for inspiration and guidance for vessel owners, which faces the difficult decision in selecting the right BWTS for their vessels and starting up projects. Additionally this study has uncovered some of the implications found in installing BWTS on board vessels with EX zones and confined spaces such as Oil & Chemical Tankers.

3. Conclusion

The cooperation between VMS, ERMA FIRST and Uni-Tankers was based on using the vessel Boringia Swan as a case study, for the purpose of developing a standard Ballast Water Treatment System approved by both IMO and a Class society to be used in vessels with potential EX zones and confined spaces.

After investigating the different solutions available, the project group came up with alternatives, which were represented by the installation of the Ballast Water Treatment System in two different locations, being in the vessel's pump room or in a deckhouse. It was chosen that the case study should focus upon an installation within the pump room, as this would treat both the confined space dilemma and installation within EX zones. Initially a solution was found where the Ballast Water Treatment System was installed within the pump room and a single component, being the electrolytic cell installed in the adjacent engine room, as this component did not possess an EX certificate at the time of analysis.

After submitting this proposal to DNV, the solution was discarded and a subsequent new solution was investigated, being to obtain an EX certificate for the electrolytic cell and install the complete Ballast Water Treatment System in the pump room as individual components.

Based on this project, ERMA FIRST is currently upgrading their additional Ballast Water Treatment Systems in order to allow their installation in cases similar to the one described in the case study of this project. To conclude, the findings of this report presents some attractive opportunities. Market-wise it presents a unique solution for the niche of vessel with EX areas and limited spaces, but also an environmental success by reducing the energy consumption and air contaminations from the vessel.

Specifically for Boringia Swan the project group has continued their collaboration and is presently looking into installing an upgrade model from ERMA FIRST named, ERMA FIRT FIT which possess a comprehensive EX approval, in the pump room. This project is intended executed in November 2015.

A side effect of this project is that the project group has continued their collaboration in developing optimized Ballast Water Treatment Systems and thus contributed with development enhancing future possibilities of installing such systems in vessels with confined space and EX zones.

Perspectives:

3.1 Social effects

This project will create additional engineering, service and installation work for the companies in Denmark. This is expected to boost and increase the opportunities of direct and indirect job positions in the region, which can lead to greater welfare in local communities.

3.2 Economic effects

This project is a key foundation for upgrading Ballast Water Treatment System on Oil & Chemical Tankers operating worldwide. For example: This project was a prerequisite for currently ongoing projects which concerns upgrading and installing of Ballast Water Treatment Systems for different shipping companies with fleets of Oil & Chemical Tankers.

3.3 Environmental effects

The dominant environmental effect of developing an EX approved system is that it can be placed in appropriate locations on board the vessel limiting the energy requirements related to pumping and treatment of the ballast water. This will result in a reduced energy consumption, thus lowering the fuel consumption and air contamination from the vessel.

An indirectly environmental effect of the system is that its installation and use in for cleansing ballast water will limit the contamination across oceans in terms of microorganisms and invasive species.

3.4 Technological new value

Presently various Ballast Water Treatment Systems exists, which fulfil IMO's requirements in terms of functionality. Contrarily many of the available systems has not obtained a full EX approval limiting the possibilities of installing these on vessels with EX zones. An EX upgraded ERMA FIRST system will thus be a technological newcomer to the market as the first system that is functionally type approved by IMO and EX approved by Class as a complete system, providing more flexible possibilities of installation.

Additionally this project provides ship owners with the possibility of installing Ballast Water Treatment Systems as an integrated unit and not on top of a deck, which could potentially be in way of other operations.

3.5 Market Potential:

On a global scale, there is around 40 manufacturers of systems for ballast water treatment. These are primarily based on two known principles, being cleansing with electrolysis and cleansing with UV radiation. Systems based on either technology contains electrical, components which eliminates the possibility installation on EX zones on-board ships with limited space available.

There are approximately around 60-70,000 vessels globally, which needs a ballast water treatment system installed in accordance to the future IMO requirements. This number of vessels will thus need the installation in a period of 5 years from the day that the IMO convention is put into action – expectedly January 1st 2016.

By developing an EX solution with point of origin in an already IMO approved system, VMS would achieve a competitive advantage by being a first mover in the market. Additionally it gives a sales-wise edge, when the system is approved by the different authorities.

4. Literature

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Enclosures

1. 1298-100-004 – B – Work Schedule
2. 1298-801-001 – Ballast Water Treatment System – Flow Diagram
3. BWTS pre-filter dimensions
4. BWTS cyclonic filter dimensions
5. BWTS power supply for electrolytic cell dimensions
6. BWTS control panel dimensions
7. EX certificates on BWTS components

Ballast Water Treatment Systems
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EX Approval of Ballast Water Treatment Systems for Oil & Chemical Tankers

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