Challenges in Ballast Water Management system

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In February 2004, the Ballast Water Convention was adopted during a diplomatic conference at IMO. The Convention entered into force on 8 September 2017 after Finland ratified the same on 8 September 2016 bringing the number of contracting states to 52, representing 35.1441% of the world merchant shipping fleet. As on date, it has been ratified by 75 states constituting 75.34% of the world's merchant shipping fleet.

The IMO Committee agreed that the entry-into-force date of the amendments to regulation B-3 of the BWM Convention would be 13 October 2019.

The Convention includes two regulations that define ballast water management standards; Regulation D-1 addresses the Ballast Water Exchange standard and Regulation D-2 details the Ballast Water Treatment Performance standard.

It was agreed by IMO that owners who have already fitted a BWMS complying with the previous G8 Guidelines (Res. MEPC. 174(58)) should not have to replace the BWMS for the life of the ship or the life of the BWMS, whichever is the sooner nor should they be penalized for non-compliance with the D2 standard provided the BWMS has been installed, operated and maintained in accordance with the manufacturer's recommendations

The trial period would be for two (2) to three (3) years following entry into force of the Convention as per the time framework approved by MEPC 72 in accordance with BWM.2/Circ.67.

During the trial period, Port States would refrain from applying criminal sanctions or detaining the ship based on only sampling.

BWMS Code:

At MEPC 72, Code for Approval of Ballast Water Management Systems (BWMS Code) was adopted for type approval of BWMS. All BWMS installed on or after 28 October 2020 are to be "type approved" as per BWMS code. BWMS approved as per previous G8 Guidelines (i.e MEPC Res. 174(58)) not later than 28 October 2018, may continue to be installed on board ships before 28 October 2020. It has also been clarified that BWMS approved as per 2016 G8 Guidelines (as per MEPC Res. 279(70)) are deemed to be in accordance with BWMS Code.

New requirements in BWMS Code which would be significant while considering the options of BWMS are as follows:

a) Salinity and Temperature**:** During type approval, testing is to be carried out across a full range of salinities (fresh, brackish and marine) and through a temperature range of 0degree C to 40degree C (2degree C to 40degree C for fresh water). BWMS unable to demonstrate successful performance across these salinity and/or temperature ranges will be assigned Limiting Operating Conditions on the Type Approval Certificate.

b)System Design Limitations**:** An important development is the concept of documenting the critical parameters known as System Design Limitations (SDL). These parameters impact the operation of BWMS (for example: minimum and maximum flow rates, time between ballast uptake and discharge) and design limits (for example: water quality expressed by oxidant demand and ultraviolet transmittance). SDLs are to be identified by the manufacturer, validated during testing and indicated on the Type Approval Certificate.

c) Bypass Arrangements**:** BWMS bypass or override arrangements, provided to protect the safety of the ship and personnel in the event of an emergency, should activate an alarm and be recorded by the control equipment.

d) Self-Monitoring**:** BWMS are to be provided with a system that monitors, records and stores sufficient data/parameters to verify correct operation for the past 24 months. Alerts are to be indicate when the system is shutdown or when an operational parameter exceeds the approved specification.

Ballast Water Management Treatment System installation is a big investment and could cost as much as $2,000,000 depending on the size and manufacturer. As for operating cost, it depends on the type of system and starts from as little as a few dollars per 1,000 m3 of treated water. Many system suppliers quote operating costs below $20 per 1,000 m3.

Some systems have very high power requirements – as much as 220 kW per 1,000 m3 of treated water.

Ballast system technology:

The technologies currently available or being developed can generally be grouped under three broad categories based on their primary mechanism for rendering the organism inactive: mechanical, physical and chemical (**Please refer Annex 1**)

Advice on the storage and handling of chemicals is contained in the IMO Circular: BWM.2/Circ.20.

Technical Challenges & System Combinations

The treatment technologies differ in method and rate of application, scalability, holding time (required for kill rates and safe discharge), power requirements, effects on other ship systems or structure (corrosion), inherent safety and costs of operation. In many cases their efficacy varies with the conditions of the ballast water, flow rates, volume of water treated and holding time. There are also issues of whether treatment is done at intake, while being held on board, at discharge, or a combination of the three.

For instance, filtration, separation and UV radiation are done during ballasting. UV radiation is also used during deballasting. These systems are sized for the maximum flow rate in the ballast system.

Conversely chemical biocides and deoxygenation are usually applied to attain a certain concentration in the water in the ballast tanks. The efficacies of these systems do not depend so much on the flow rate of the pumps as the time the ballast is allowed to remain in the tanks to achieve the desired kill rate. Short voyages can be a problem for these technologies.

Matching the treatment technology to the ship type, or more accurately the ballast system type, and vessel service is the key to designing a successful ballast water.

The most prevalent system types are ones that combine mechanical separation / filtration with UV radiation or chemical disinfection. The initial mechanical separation/filtration is used to remove the larger organisms in order to increase the effectiveness of the secondary treatments.

Points to be considered while preparing BWMS Procurement specification

In order to select a suitable system, ship operators will need to prepare a Procurement Specification for potential suppliers, which details their technical requirements. This should include the following information:

- The ballast water pump flow rates that the management treatment system will be required to cope with (note: the treatment equipment capacity should be greater than the ship's ballast rate to allow for an operating margin).
- A copy of the ballast system pipe work diagrams showing the connections, pumping capacities and valves.
- Compartment details for the installation of treatment equipment and storage of consumable materials.
- Power supply availability and routing for control cabling.
- Certification requirements
- Details of the ballast tank coatings

Problems encountered on BWMS in operation:

1. Many systems employ TRO (total residual oxidant) measurement during neutralization and some systems use TRO measurement to determine disinfectant dosage during ballast water uptake. Many owners find difficulty in that the reagents used for TRO measurement were highly susceptible to improper storage and handling which has an effect on TRO sensor abnormalities.
2. The sensor calibration is a repeated problem for both TRO and oxygen measurement, where applicable. Additionally, vessels with UV systems reported that the cost and frequency of UV lamp replacement was a significant concern.
3. The reduction of ballast water throughput during both uptake and discharge affecting efficiency of BWMS. This may be linked to filter clogging and cleaning. It was noted that this may also be associated with the ballast practices.

Design consideration during New construction:

1. The design should consider all of the spaces necessary to accommodate BWMS filters. The Total Residual Oxidant (TRO) sampling lines should also be reviewed to make sure they are large enough for in-service cleaning.

2. Some pumps, such as the fire and general service pumps, may go offline when the ballast water treatment (BWT) system is tripped off. This can be avoided if the control system, which is integrated with the ship system is programmed in such a way that it will remain online with the ship system.
3. Vacuum breaks may be considered for ultraviolet technology systems in deck installation as the insufficient water flow in UV reactors and chambers can cause inadequate UV bulb cooling.
4. Factory Acceptance Testing (FAT) is strongly recommended for manufacturers with limited experience to determine if the requirements specified in the contract are met. The contract should also clearly list all of the spare parts required on board. Moreover, a definition of a successful trial run of the BWTS installed is recommended to be included in the contract.
5. Since ballast water is not exchanged in the case of BWTS, sediment control may become a problem. Fine filtration rates (40 micron) support the filtration and removal of large microorganisms, but will not prevent the build-up of fine silt in the tanks. Ultrasonic cleaners for the filters to remove heavy sediment build-up may be used.

Design consideration during retrofitting:

1. The installation of large filters with back flush must consider both low and high sea chests as well as the athwart ship orientation. Consideration must be given to the potential presence of silt and primary berthing orientation.
2. Avoid tying filter backflush overboard into ballast discharge overboard piping; this defeats the purpose of keeping backflush from one operating area separate from treated ballast water overboard discharged to another operating area.
3. To make a decision on the proper testing location and incorporate the requirements into the contract. Testing at sea, BWMS commissioning is not an adequate challenge since vessels in reality ballast more often in port than in open sea. But most shipyards are not suitable, both in depth and water quality, for conducting proper BWMS testing. Also sea trials may not demonstrate efficacy in high silt loading (port) condition either.
4. For vessel using UV systems, validating the proper UV lamps warm up and verifying cool down capabilities before turning them on for the first time is recommended. For chemical systems, the TRO monitoring should be started early.
5. It is recommended to clean the ballast tanks before putting the system in service.
6. The start-up and shut-down sequence is to be established during the design phase. The UV bulbs may not meet their expected life-cycle durations in case of cooling water interruptions and frequent start up and shut down sequences Inadequate shut-down sequence plans may cause improper cooling of lamps and even trigger the BWTS to go offline. It is difficult to reprogram the sequencing during operation. Therefore the program ought to be designed and tested during installation and validated during commissioning.
7. The backflush lines should be led directly overboard. The back-flushing rate should be carefully monitored and adjusted. The adjustments may be done by using appropriate sea chests, changing pressure settings, switching between filter candles and other adjustments. Proper pipe flushing arrangement will help prevent sediment.

Contingency measures:

At its seventy-second session, the Marine Environment Protection Committee (MEPC) invited Member Governments and international organizations for submissions of proposals for when elements of the Guidance on contingency measures under the BWM Convention (BWM.2/Circ.62) should be included in ballast water management plans (BWMP). It was recognized that the inclusion of information on contingency measures in the BWMP is important and should be done as soon as possible.

A clearly written contingency plan for all foreseeable maintenance and repair (M&R) events will be helpful. The ballast water exchange may work as a contingency for ballast water treatment. The BWMP should anticipate this and include details on notifying and obtaining concurrence from concerned flag states and ports. The possibility of having a ballast manifold on deck, alternative BWTS, and special statutory requirements are part of contingency measures.

Owners should pay attention to each country’s specific requirements. For instance, Argentina recently announced a requirement that all ballast water must be treated with chlorination before discharging.

In respect of above, the owners and shipyards are advised to take note of the IMO stand and start incorporating the contingency measures while submitting BWMP for approval. Apart from the IMO guidelines, the reference documents with respect to the contingency measures could be followed as submitted to the IMO and the summary of which are as follows:

1. MEPC 73/4/8 Submitted by IMarEST

This document identifies four areas related to contingency measures that might be included in the BWMP:

- contingency measure elements from BWM.2/Circ.62;
- Corrective actions applicable to ballast water management systems (BWMS)that might eliminate the need for contingencies;
- Corrective actions applicable to BWMS that might increase the effectiveness of contingency measures; and
- Preparations for port-based and/or shore-based contingency measures.

Ballast water exchange (BWE) through the BWMS has been identified as a potential contingency measure (MEPC 73/INF.8). It is noted that this method often requires a sequential BWE, which requires analysis to assure that ship stability is maintained and hull stress limits are not exceeded.

Should BWE through the BWMS as a contingency measure be considered, then the BWMP should include detailed instructions on how to safely perform this measure.

2. MEPC 73/4/6 Clarifications on article 3.2(f) of the BWM Convention by China

This document seeks clarifications on article 3.2(f) of the BWM Convention regarding "permanent ballast water in sealed tanks on ships, that is not subject to discharge", for the purpose of global implementation of the BWM Convention in a consistent manner

Some existing ships, especially those with short routes in sea areas where ballast water Exchange in accordance with regulations B-4.1 and D-1 is not possible, as well as ships for which the ballast/deballast operations are not frequent, such as ro-ro passenger ships, are facing serious difficulties in conducting ballast water exchange and installing a ballast water Management system (BWMS), and it is also not feasible for them to use reception facilities in Ports. Under such circumstances, If the design and operation of the ballast water system of a ship are considered as within the scope of article 3.2(f), such a ship does not need to meet the requirements of the BWM Convention. It is neither subject to survey and certification according to section E of the BWM Convention, nor required to have on board a ballast water management plan (BWMP) and a ballast water record book (BWRB).

Different understandings and implementations of article 3.2(f) of the Convention will lead to completely different results for ships using the same approach of ballast water management. In one opinion, such ships are not required to comply with the Convention, while with the understanding of another opinion, such ships are required to comply with the Convention. According to a middle Opinion, ships are required to be surveyed and be issued with a "Statement of Fact" instead of an IBWM Certificate. China prefers middle option.

3. MEPC 73/INF.3 Guidelines for ballast water exchange and sediment management in Wider Caribbean Region areas

Training on BWMS:

The lack of uniformity in training methods, especially when the BWMS is ship specific is considered as a major deficiency for proper functioning of BWMS.

The more comprehensive training materials, including a well-written, ship-specific, operating instruction manual that is both detailed and updated after the installation.

Foe large fleets that consist of different BWTS, the shipboard crews that are trained for one type of BWTS, but may not be able to apply their knowledge when working on a different vessel with another type of BWTS. Therefore, placing shipboard crew on board different vessels with different BWTS, will allow them to gain exposure and a more diversified experience conducting various BWTS operations.

The technical managers and port engineers may be encouraged to do the training program as well. Having technical managers who are competent in BWTS operation for multiple system types will be beneficial.

Understanding the technical aspect of BWTS might not always be enough for immediate operation, especially for a retrofit BWTS that has been modified. Training should focus on the operation of BWTS.

Sampling of ballast water:

Though sampling is not an international requirement as of now, with D-2 compliance approaching, a sampling protocol should be included in the training. A detailed instruction of proper sampling procedures would be helpful along with hands-on training and a defined record keeping process.

Other alternative sampling methods, such as third-party sampling onboard or onshore can be explored as well.

Data Storage:

Current BWTS are installed with data auto-log and proper data storage is sometimes neglected. The data logging should be checked and verified regularly and each system should store at least one month of data. This data may be requested for port state control and USCG review.

Data is also important to the ship owners as they can identify valuable trends regarding the performance of the BWTS.

Challenges faced by Ship owners:

It is learned that almost 50 percent of the systems were being operated on board ships and the remaining systems were either inoperable or considered problematic.

The more prevalent challenges that shipowners and operators have faced with these systems are related to software, hardware, and the crew's ability to operate the systems correctly.

The software integrated into the ballast water management systems often required extensive updates and have experienced system malfunctions.

System operators have had a difficult time with hardware maintenance and maintaining appropriate spare parts on board.

List of BWMS approvals by IMO and respective Administrations:

List of ballast water management systems that make use of Active Substances which received Basic Approval from IMO

Table (1) given in the following link may be referred for list of ballast water management systems that make use of Active Substances which received Basic Approval from IMO.

http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Documents/Table%20of%20BA%20FA%20TA%20updated%20August%202018.pdf

List of ballast water management systems that make use of Active Substances which received Final Approval from IMO

Table (2) given in the following link may be referred for list of ballast water management systems that make use of Active Substances which received Final Approval from IMO.

http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Documents/Table%20of%20BA%20FA%20TA%20updated%20August%202018.pdf

List of ballast water management systems which received Type Approval Certification by their respective Administration (resolution MEPC.228(65))

Table (3) in the following link may be referred for list of ballast water management systems which received Type Approval Certification by their respective Administration under resolution MEPC.228(65).

http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Documents/Table%20of%20BA%20FA%20TA%20updated%20August%202018.pdf

USCG type approvals:

https://cgmix.uscg.mil/Equipment/EquipmentSearch.aspx

Some Classification societies including IRS has been working on various issues regarding BWMS and can help stakeholders for a successful implementation on board. Some of the areas which could be helpful are as follows:

1) It was reported that 43 percent of running BWTS worldwide are not being sampled and tested. Though it is not an international requirement as of now, with D-2 compliance approaching, a sampling protocol should be included in the training.

a. Other alternative sampling methods, such as third-party sampling onboard or onshore can be explored as well.
b. IRS can provide a detailed hands-on-training and instructions on proper sampling procedures would be helpful along with hands-on training and a defined record keeping process.

2) Ballast tank sedimentation: Flow mixed with solid particles (e.g. mud) causes the sedimentation in long run, typically in ballast tanks causing the species to be left in tank even after drawing out ballast water. IRS can perform Flow analysis in order to study the flow pattern and the sediment formation. Possible solution as design changes (after observing dead zones in tanks) can be suggested.
3) Guidelines on BWM convention and type approval (already published on IRS website).
4) Guidelines to manufacturers for taking Basic Approval and Final Approval of their BWM using active substances from IMO.
5) Guidelines to Ship Owners for carrying out assessment of technical offer made by BWMS supplier.
6) Technical Report/Guidelines on BWMS methodologies.

Disclaimer: Views expressed in above paper are author's own views and do not necessarily reflect those of Indian Register of Shipping.

Annex I : Categorization of BWMS technologies :

Technology	Disinfection while ballasting operation			After-treatment while de-ballasting operation			
	Whether use active substance	Whether ballast water is passing through the BWMS	Whether ballast water is passing through the BWMS - Only a small part to generate the active substance	Whether ballast water is passing through the BWMS -	Whether Injection of air to the piping and Inert Gas to the tank	Whether Injection of neutralizer	Not required by the Type Approval Certificate issued by the Administration
In-line UV including UV + Advanced Oxidation Technology (AOT) or UV + TiO2 or UV + Plasma		yes		yes			
In-line Flocculation	yes	yes					yes
In-line membrane separation and de-oxygenation (injection of N2 from a N2 Generator)		yes					yes
In-line de-oxygenation (injection of Inert Gas from Inert Gas Generator)		yes			yes		
In-tank de-oxygenation with Inert Gas Generator	In-tank technology: No treatment when ballasting or de-ballasting						
In-line full flow electrolysis	yes	yes				yes	
In-line side stream electrolysis	yes		yes			yes	
In-line (stored) chemical injection	yes					yes	
In-line side-stream ozone injection without gas/liquid separation tank and without Discharge treatment tank	yes					yes	
In-line side-stream ozone injection with gas/liquid separation tank and Discharge water treatment tank	yes	yes		yes		yes	
In-tank pasteurization and de-oxygenation with N2 generator	In-tank technology: No treatment when ballasting or de-ballasting						