Ballast Water Management on Ships

by Mr. Rajoo Balaji

1.0 INTRODUCTION

Ballast, in practical terms, refers to the weight added to ships to maintain stability. From wooden ships to modern steel vessels, ballast addition has been a regular practice when a ship becomes light after discharging its cargo. When the vessel reaches port to load cargo again, this ballast has to be gotten rid of, a process which is known as deballasting. For a ship-owner, the carriage of ballast is an unproductive phase in ship, and for the ship's personnel, ballasting and deballasting are inevitable exercises which add to the operational workload. As ships get bigger and deep drafted, the significance of ballast increased as ballast was carried not only for sea-going stability but also for propeller immersion.

Through the ages, wooden ships carried solid ballast in the form of stones, sand, tiles and heavy materials of sorts. When trading increased in volume and technology developed, steel ships replaced the wooden fleet. With riveting, followed later by welding techniques, assuring structural integrity, ships began to use seawater as ballast. Seawater was easily available and easily filled the tank spaces. The functional convenience of pumping the water made ballasting and deballasting quicker and easier.

Pumping rates can be in the high range of 5000-15000m^3/h [1] and large vessels typically carry a ballast of about 30 to 45% of their dead weight tonnage [2-3]. It is estimated that almost 3 to 5 billion tonnes of ballast water is being shifted annually around the globe [2]. Requirement for additional installed power and equipment, extra workload and tank corrosion have been identified as the harm caused by ballast water, but these voluminous shifts are causing another harm of greater concern, namely, ecological imbalance. This article attempts to bring awareness of the technological activities the shipping industry is currently experiencing due to this.

2.0 HARM OF INVASIVE SPECIES

The water which is loaded as ballast contain marine organisms of varying sizes, and these are carried and released with the water at the loading destination of the ship. The organisms are considered alien and, in most cases, are invasive in nature. Other than microorganisms, non-indigenous organisms such as mice, rats, cockroaches, jellyfish, crabs, fish *etc*., are supposed to have been transported by ships [1].

The impact of these biological invasions by way of spreading diseases, the extinction of native species and ecological imbalance *etc*., came into strong focus in the 1980s. It is on record that remedial actions have cost millions of dollars. The European zebra mussel fouling of the Great Lakes, the finding of Japanese dinoflaggallates in Australia and the carnivorous North American jellyfish in the Black Sea can be cited as examples [4]. Table 1 highlights the harmful effects of some of the organisms. It is to be noted that these harmful effects and the species listing are neither exhaustive nor comprehensive. Of the environmental threats that are affecting the oceans of the world, the topmost four threats that have been identified are the shifts of species, land-sourced pollution, climate change and excessive fish harvesting [5]. In addition, shipping has been identified as a vector that contributes almost greater than 90% of the shifted species [6].

Table 1: Harm Caused by Marine Invasive Species [5, 11]

Organism/Species	Potential Harm
Cholera (*Vibrio cholera*)	Cholera epidemic
Cladoceran Water Flea (*Cergopogis pengoi*)	Clogging of fishing nets, trawls *etc*.
Mitten Crab (*Eiocheir sinensis*)	Invasive. Preys on native species and depletes population. Can travel inland through fresh waterways and affect food webs
European Green Crab (*Carcinus maenus*)	Invasive. Preys on native species and depletes population
Zebra Mussel (*Driessena polymorpha*)	Fouling, alteration of habitats
Asian Kelp (*Undaria pinnatifida*)	Alteration of habitats
Toxic Algae	Oxygen depletion, release of toxins and killing of marine organisms. Consumption of contaminated seafood can cause illnesses and death in humans

3.0 IMPACT ON MALAYSIAN WATERS AND SHIPPING

Peninsular Malaysia, with its geographical location and total coastline of more than 4500km, harbours potential habitats which are being exposed to the species transported by ships. Apart from the threat faced by dependant

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fishing activities, other sectors such as tourism, human health and the rich biodiversity will also be harmed. The Malacca Straits experiences an average of 600 ships/day and up to 70000 passages have been recorded annually[5]. An increase in the number of ports and trade has also further increased the number of ships plying these waters. Realising the vulnerability of the situation, Malaysia has been proactive in addressing the concerns of the international shipping community and has laid out regulations typically in alignment with many other countries [7].

4.0 BALLAST WATER MANAGEMENT (BWM): CURRENT PRACTICES

The International Maritime Organisation (IMO) has initiated measures to mitigate this harm. Although the IMO Convention awaits full ratification, the industry has been gearing itself for the regulations. Two approaches have evolved, of which one is purely operational, while the other is based on water treatments which are trying to address the standards on species count set by IMO as shown in Table 2. It needs to be mentioned that standards set by some of the US States are stricter. The Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) of 2004 targets 2016 for ships to fully comply with the Regulation D2 Standards as projected in Table 2.

Table 2: IMO ballast water performance standards

Organism Size Class	IMO D2 Standards
Organisms greater than 50μm in minimum dimension	<10 cells/m^3
Organisms 10-50μm in minimum dimension	<10 cells/ml
Escherichia coli	<250cfu/100ml
Intestinal enterococci	<100cfu/100ml
Toxicogenic *Vibrio cholerae*	< 1cfu/100ml or < 1cfu/gram wet weight zoological samples

1. BWT systems must meet the IMO D-2 Standards.
2. cfu: Colony Forming Unit. A measure of viable bacteria numbers.
3. μm: One millionth of a metre

The operational approach, which is presently being followed by many ships, involves exchanging the ballast water as the ship moves in the sea. When the ship reaches the load port, the ballast water which is pumped out will not be the water loaded at the discharge port. The principle of this method is based on the premise that species from coastal waters cannot survive the deep ocean ambience. Furthermore, the densities of species in open seas are much lesser than that of coastal waters, so the water exchanged in the open seas will have a very low percentage of species.

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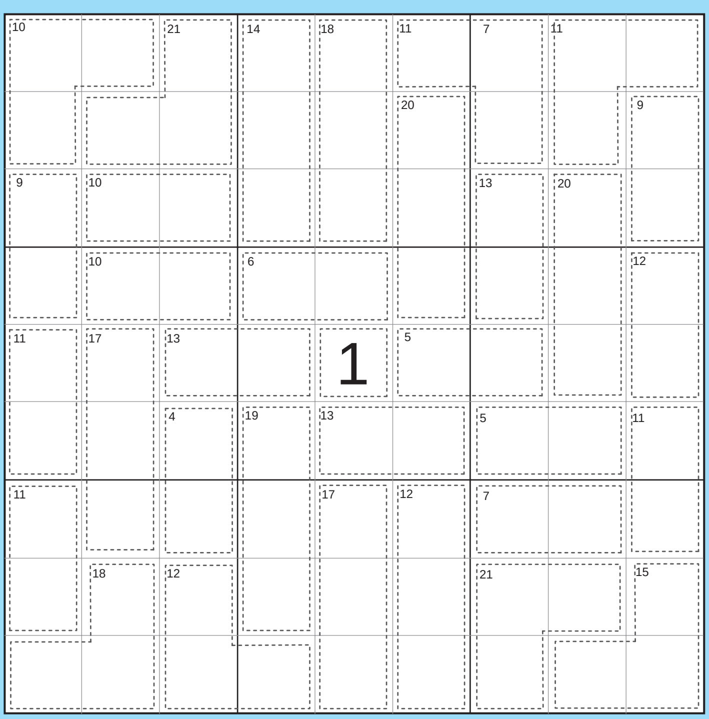

1SUDOKU

Centerpiece "1"

by Mr. Lim Teck Guan

About the puzzle:

In this Sudoku variant, only 1 number is given as clue, thus the name 1Sudoku. The rest of the clues are given in the numbered cages (the dotted frame encompassing 2 or more squares). You are to search for the right combinations to fit the total for the cages and end up with a Sudoku Grid, the 9 by 9 composite of squares where there is no repeat of the number 1 to 9 in every Row, Column or Block.

Fill in the remaining 80 squares with single digits 1-9 such that there is no repeat of the digit in every Row, Column and Block. The number at the top left hand corner of the dotted cage indicates the total for the digits that the cage encompasses.

For tips on solving, visit www.1sudoku.com.my

Answer is in the following pages of this edition.

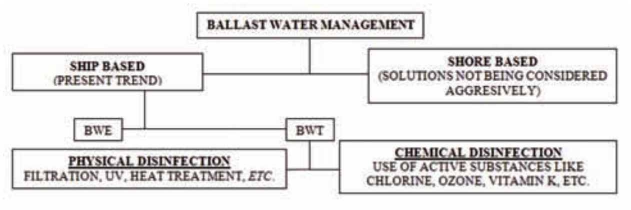

Figure 1: Ballast water management - Present options

Two broad methods of ballast water exchange (BWE) are being followed, namely, the Flow through Method and the Sequential Method. In the Flow through Method, water is pumped in through the tanks' bottoms and the water already present in the tank is displaced by overflowing the tank. The Sequential Method involves replacing water from the tanks in a sequence. Both the BWE methods, though simplistic, have serious issues. Apart from the additional workload for the ship's personnel, the efficiencies have proven to be inconsistent [8] and have also shown excessive hull girder stresses due to the volume/weight shifts [9]. Other exchange practices basically follow one of these methods with some variation in approaches. Considering the demerits and requirement for a stricter regimen, treatment technologies are being developed. The technologies require type approval and many solutions are commercially available to ship-owners. Figure 1 shows the BWM options.

5.0 BALLAST WATER TREATMENT (BWT) TECHNOLOGIES

Though possibilities of shore based treatment are being debated, the orientation has been towards shipboard management of ballast water by treatment methods replacing exchange methods. Almost all the BWT solutions have been developed from the experience of wastewater management technologies and most of the solutions are a combination of two to three technologies. The capital and operating costs of these emerging technologies are very high. On average, the operating costs average \$30 to \$130 per 1000m^3/hour of treated water [10]. Capital costs range from \$287,000 to \$779,000, depending on the flow rates [10]. The reasons for the high costs may be attributed to the newness and recovery of research costs, apart from the conventional costing factors.

Though both physical and chemical methods are effective in species elimination, chemical methods fare better in comparison. The recurring costs of chemicals, storage, harm to human health and other marine life are some of the looming concerns of the chemical methods.

Table 3: BWT: Cognisable technologies in contention

Method	Principle	Remarks
Filtration	Sediment and particles removal by disc and screen filters	System designs based on size and shape of particles Require periodic cleaning/back-flushing Parallel assembly of many filter units Filtration grade down to 100/50 /20µm
Cyclonic Separation	Separation of solid particles due to centrifugal forces Acceleration of the water by internal flow direction inside the facility	
UV Radiation	Inactivation of organisms and pathogens by breaking the cell membrane	Established technology UV radiation at approx. 200nm. can destroy cellular components Low pressure drop in water system
Cavitation	Slit plates or venturi pipes generate cavitation bubbles High local energy due to implosion of bubbles inactivate organisms	Acoustic Systems: Transducers apply sound energy at specified amplitude and frequency Sound energy causes cavitation. Resulting mechanical stresses disrupt the cells
Electrolysis	Electronic ionisation by means of electric current Generation of chlorine/chlorine dioxide as disinfectant	
Chemical Additives	Direct addition of chemical additives to the ballast water that have disinfector actions	Oxidising and nonoxidising biocides: Chlorine and ozone are the widely used oxidising biocides Organic structures like cell membranes destroyed by strong oxidisers Nonoxidising biocides interfere with reproductive, neural, metabolic functions Applicable for big volumes
De Oxygenation Gas Super Saturation	Removal of dissolved oxygen in ballast water and replacement by inactive gases	With removal of oxygen, most of the organisms (exception: cysts, spores or anaerobic bacteria) Oxygen can be removed by introducing inert gas or by addition of chemical additives Controlled atmosphere in tanks is needed to avoid re-oxygenation
Thermal Techniques	High temperature sterilisation of water	Use of heat source from ships
Electric pulse and pulse plasma techniques	Application of electric field or pulse to kill organisms	
Magnetic Fields	Water is passed through ferromagnetic/ electromagnetic devices. Magnetic flux supposedly alters the organic and inorganic constituents	
Biological Techniques	Control of organisms achieved by introducing additional organisms (predators, pathogens or competitors of concerned species)	
Anti-fouling coatings	Reduces biological fouling by toxicity, ablation or surface activity	Expensive Banned for use on ship's under-water hulls

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Some of the chemical systems, like those employing chlorine, require end control to reduce the harmful percentage of the chemical prior to discharge. Table 3 highlights most of the technologies being researched and adopted.

6.0 CONCLUSION

Globally and locally, the shift of invasive species through ballast water has been recognised as a problem of serious concern. As of 30 September 2010, 27 countries representing 25.32% of the world's tonnage (IMO) have ratified the BWM Convention, whereas a minimum number of 30 countries representing not less than 35% of the gross tonnage are required for full ratification [11]. New treatment technologies and those highlighted herein will witness research activities on grounds of economic and technological viabilities. ■

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