MariEMS Learning Material - Ballast Water Management

This is the third compilation by Professor Dr Reza Ziarati on the work of the EU funded Erasmus + MariEMS' partners and material researched by Chief Engineer Mohammed Haque. The material is composed from Chapter 8 represented here as Chapter 4.

4 Ballast Water Management (BWM) and Energy Efficiency

4.1 Introduction

Ballast water (BW) is essential to control trim, list, draught, stability and stresses of a ship. Ballast water activities are largely regulated not only because of the above ship's safety implications but also since they have been recognized to be a pathway for the movement of undesirable and alien bio-species from their natural habitat to other ecosystems (Figure 4.1.1).

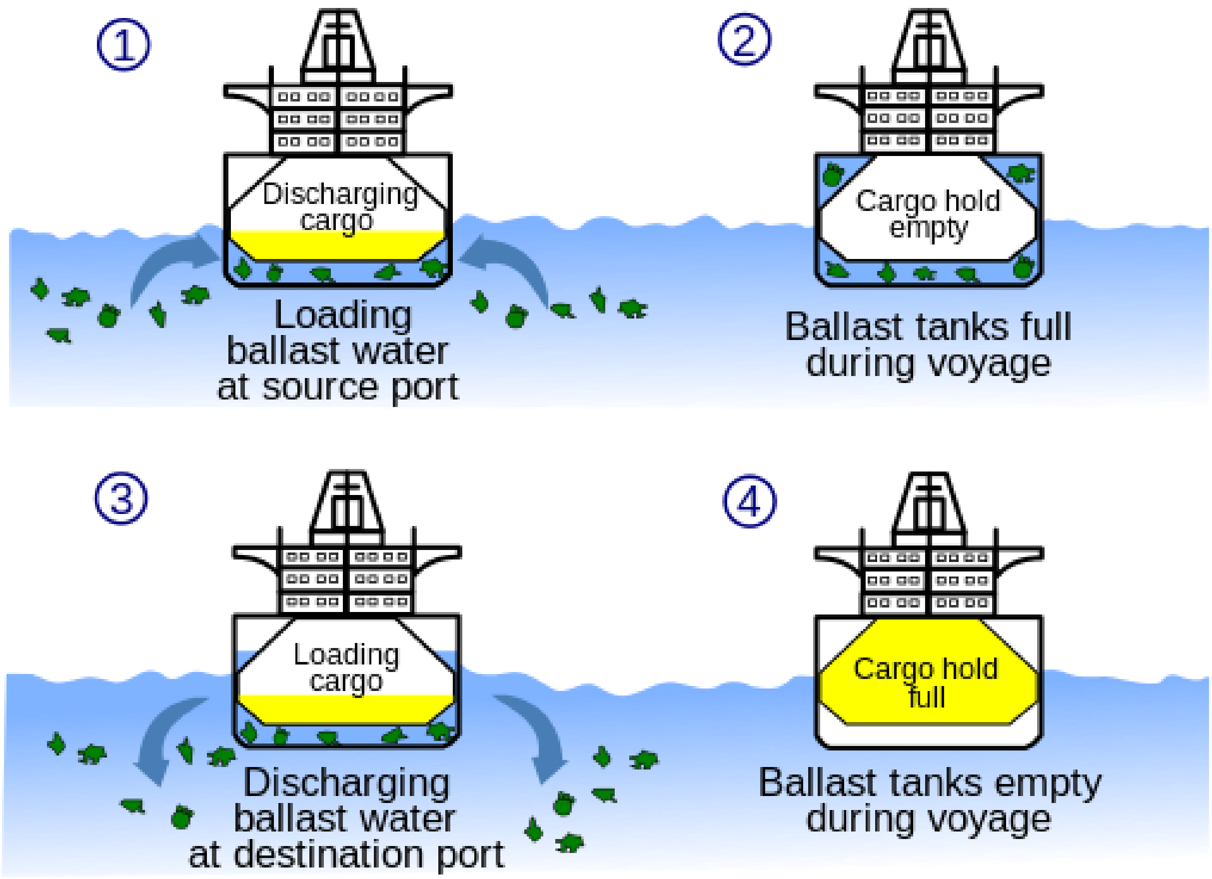

Figure 4.1.1: Transfer of bio-species due to ballast operations [Wikipedia]

Today, a full IMO Convention is devoted to ballast water management. In this Convention, two main methods are highlighted: ballast water exchange (Regulation D-1) and achievement of ballast water standards (Regulation D-2). The impact of Ballast Water Management (BWM) on a ship's fuel consumptions is not normally considered despite the evidence that, regardless of the management method established, the overall energy efficiency of a ship is affected by ballast water because:

- The ballast exchange requires the additional use of the ballast water handling equipment and in particular pumps.
    - Treatment systems developed to reach D-2 standards require the installation of additional energy consuming equipment on board ships.

In addition to the increased use of ship-board power due to additional ballast treatment equipment, ballast water impacts the ship's energy efficiency in two additional ways:

- The change in ship displacement; thus wetted surfaces and ship resistance. Generally, the more ballast water or ballast sediments are carried around, the bigger the ship displacement will be and the higher ship's energy consumption is expected.
- The change in ship trim: Trim optimisation via the effective use of ballast water could lead to gains in energy efficiency as has been discussed in the previous section.

In ballast water operations and management, one should use considerable foresight in choice of regulatory compliance methods due to the fact that many variables such as type and size of ship, ballast tank configurations and associated pumping systems, trading routes and associated weather conditions, Port State requirements and manning would impact the choice of the system.

4.2 Port and Voyage Planning Aspects

The amount of ballast water discharge/uptake in a port depends on type of vessel, amount cargo loaded/un-loaded and ship loading planning. The need to counterbalance the detrimental effects of weight distribution during and after loading/unloading must be addressed in ports. The cargo distribution should be considered as having an impact on the quantity of ballast as well as on the ability to optimize the trim without jeopardizing the ship's strength and stability. Therefore, the port and ship responsible persons must develop plans and procedures to optimize the ballast water intake through the establishment of the cargo loading/unloading process and the final cargo plan. In addition to the anticipated ballast plan, the dynamics of the voyage should be taken into account especially when ballast water exchange has to be carried out. Ballast water and trim optimisation and adjustments while in passage should be pre-planned relative to the port operations that normally give and even-keel no trim. Sediment uptake and removal should be controlled as part of voyage planning to ensure the minimal level of sediments. As part of voyage and daily activity planning, the case for these two should be included and discussed. The voyage should be planned taking into account when ballast water exchange or adjustments are to be carried out. Also, trim optimisation and adjustments, while in passage, should be pre-planned relative to the port even keel operation.

4.3 Typical Ballast Water Systems without Treatment

Figure 4.3 shows a typical ship's ballast water engineering system. It is comprised of ballast pumps, relevant piping system and flow control methods. This system is normally installed according to IMO guidelines and is operated in accordance with the system design criteria and the manufacture's operational and maintenance instructions.

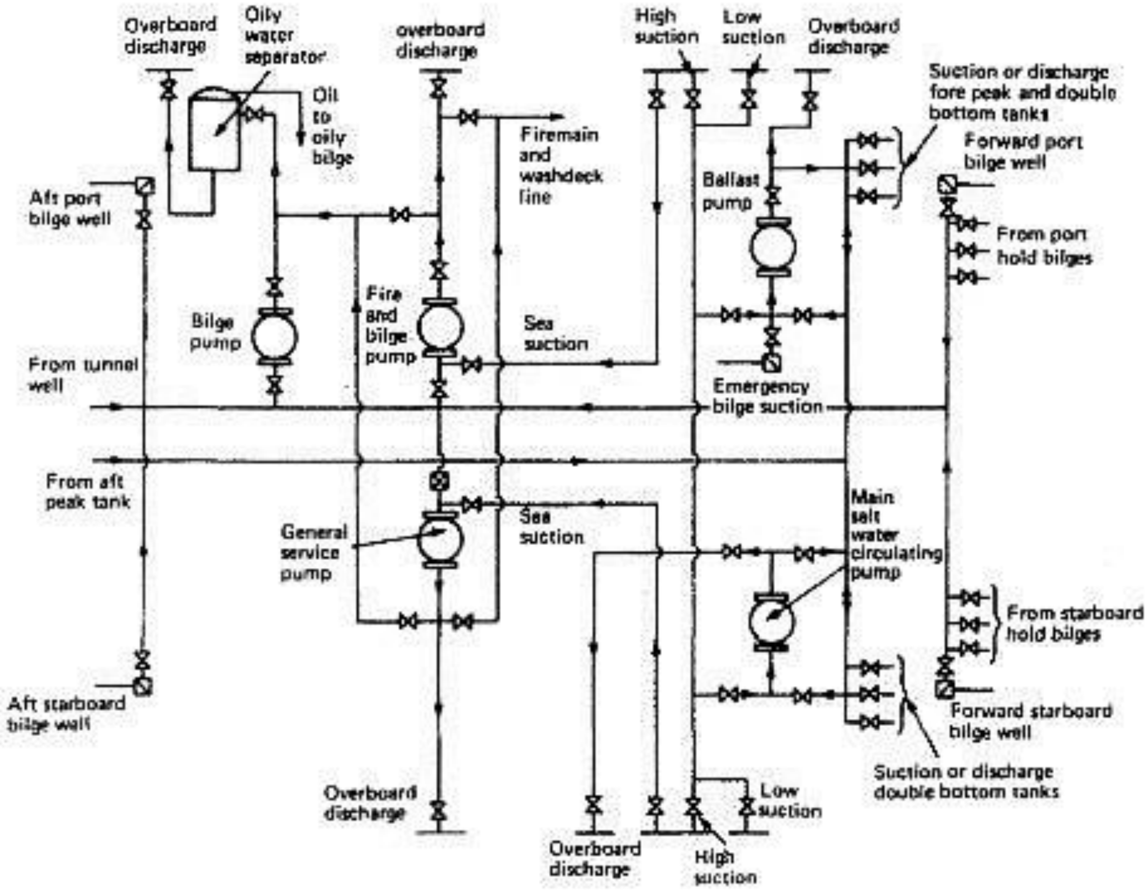

Figure 4.3.1: Typical ballast and bilge pump arrangement [Machinery Spaces.com]

The ship-board use and operation of such a system is normally described in the ship's Ballast Water Management Plan (BWMP). All failures and malfunctions of the system are recorded in the Ballast Water Record Book (BWRB) according to IMO requirements.

4.4 Ballast Water Management Plan (BWMP)

As soon as the Ballast Water Management Convention enters into force, it will be a requirement for each applicable ship to have a BWMP that specifies requirements for this purpose (most ships currently have such a BWMP in different formats).

The following are normally included in the BWMP:

- Acceptable methods for ballast exchange and relevant procedures.
- Details of the procedures for the disposal of sediments at sea and to shore. Method of the use of port reception facilities for sediments.
- Designation of the on-board officer-in-charge of the implementation of BWMP. The identification of a responsible person should enhance the planning of BWM operations. In this respect, adequate training of such crew members should encompass awareness on the energy efficient operation of the BWM equipment and optimization for deadweight management and trim optimization.

- Method of the sediment removal or reduction at sea, and when cleaning of the ballast tanks takes place.

Principle of sediment management:

To reduce the sediment levels, the following general advice is provided by the IMO:

- All practical steps should be taken during ballast uptake to avoid sediment accumulation.
- When sediment has accumulated, consideration should be given to flushing tank bottoms and other surfaces when in suitable areas.
- The volume of sediment in each ballast tank should be monitored on a regular basis.
- The frequency and timing of removal will depend on factors such as sediment build up, ship's trading pattern, availability of reception facilities, work load of the ship's personnel and safety considerations.
- Removal of sediment from ballast tanks should preferably be undertaken under controlled conditions in port, at a repair facility or in dry dock.
- The removed sediment should preferably be disposed of in a sediment reception facility if available, reasonable and practicable. Disposal should take place in areas outside 200 nm from land and in water depths of over 200 m.

Officer-in-charge: Basic tasks and responsibilities held by the officer-in-charge according to IMO guidelines include:

- An officer should be made responsible to ensure the maintenance of appropriate records and to ensure that ballast water management procedures are followed and recorded.
- When carrying out any ballast water operation, the details need to be recorded in the Ballast Water Record Book.

The officer-in-charge of ballast water management should perform the following duties:

- Ensuring that the ballast water operations follow the procedures in the BWMP.
- Ensuring that the Ballast Water Record Book and any other necessary documentation are maintained.
- Being available to assist the inspection officers authorized by a Party8 for any sampling that may need to be undertaken.

Since the Ballast Water Management Convention has not yet entered into force, the management of BW is not a worldwide obligation. However, an increasing number of countries require proper BWM before arriving in their waters. Currently, a small amount of the world's fleet carries BW treatment systems. Thus, the present dominant technique to manage BW is through the "ballast water exchange".

4.5 Methods of Ballast Exchange

There are three methods of ballast water exchange which have been evaluated and accepted by the IMO. The three methods are the sequential method, the flow-through method and the dilution method.

- Sequential method – A process by which a ballast tank is first emptied and then refilled with replacement ballast water to achieve at least a 95 per cent volumetric exchange.
- Flow-through method – A process by which replacement ballast water is pumped into a ballast tank, allowing existing ballast water to overflow from the tank (see Figure 4.5). For effective ballast exchange, the volume of flow through water should be at least 3 times the volume of the water in the tanks.
- Dilution method – A process by which replacement ballast water is supplied through the top of the ballast tank with simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank throughout the ballast exchange operation.

Figure 4.5: Ballast water exchange using flow-through method

For ballast water exchange, particular care should be taken of the following:

- Stability, which is to be maintained at all times as regulated by the IMO or flag or port authorities.

- Longitudinal stress and torsional stress values, not to exceed permitted values with regard to prevailing sea conditions, where applicable.
- Sloshing (Sloshing in ships refers to the movement of liquid inside a tank due to ship motion. Strictly speaking, the liquid must have a free surface to create a slosh dynamics problem) impact reduction due to water movement should be considered in order to minimise the risk of structural damage, in particular at non-favourable sea and swell conditions.
- Wave-induced hull vibrations when carrying out ballast water exchange.
- Limitations of the available methods of ballast water exchange in respect of sea and weather conditions.
- Forward and aft draughts and trim adjustment, with particular reference to bridge visibility, slamming, propeller immersion and minimum forward draft; and energy efficiency (optimum draft).
- Additional workloads on the master and crew.

As explained, the ballast water exchange process has implications for both safety and energy use. Also, it is shown that trim optimisation has a significant impact on ship energy efficiency.

Energy Efficiency Aspects

In general, observing the following will lead to energy efficiency:

- **Carrying less ballast water:** The displacement of a vessel is a function of lightweight, fuel, cargo and ballast weights. As such, less ballast water means lower displacement and lower resistances (or more cargo). Therefore, it is generally desirable to have less ballast from an energy efficiency point of view. Of course this should not contravene any of the regulations nor compromise ship safety.
- **Optimizing use of the equipment**: This item relates to the use of ballast water equipment via management of the amount of ballast water to uptake, discharge, correct method of uptake/discharge and so on. The aim would be to reduce or optimise the usage of relevant ship-board equipment.
- **Efficient ballast management operations:** This means performing ballast exchange or ballasting and de-ballasting in a way that is more energy efficient.

For example:

- Gravity assisted ballast exchange is preferred to simple pumping in/out processes. When the gravity-assisted method is used, there is less need to run the ballast pumps.
- Sequential ballast exchange method, where tanks are first de-ballasted and then ballasted again is more energy efficient than the “flow-through ballast exchange” method, where the thanks are allowed to overflow. Again, this is

for reasons of the amount of water that needs to be displaced; thus the number of hours for ballast pumps to operate.

- Trim optimisation: Ballast water is used to adjust the ship trim as discussed before. Trim optimisation using ballast water leads to significant energy savings on some ships.
- Steam driven ballast pumps: In some ships, ballast pumps are steam driven. The use of a boiler for this purpose is extremely inefficient. Therefore, minimisation of the use of steam-driven ballast pumps by better planning of the ballast water operations can lead to energy savings.
- Sediment removal: It is usual to take in sediments as part of ballast water operations. These sediments could be heavy and thus causes higher ship fuel consumptions when they are carried around. Thus, sediment removal leads to better cargo capacity and better energy efficiency.

References and further reading

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