Environmental Impacts, Risk and Safety, and Economic Aspects of Ballast Water Treatment Methods

Executive Summary

To provide a consistent basis for comparing the individual ballast water treatment techniques, a theoretical case study approach was used. Data on the case ship and sample voyage was specified and provided to the technical developers in the project, as well as a list of data needed for assessing cost, environmental effects, and hazards.

Risk and safety effects

For the risk and safety assessment of ballast water treatment methods, hazard identification was carried out and some recommendations for potential risk control measures were provided. Hazards can be considered from the perspective of safety/survivability of the vessel and safety of the crew during ship operations. Categories of hazards related to operation of the ballast water treatment methods include physical hazards such as heat, electrical hazards, ultraviolet or ultrasound radiation hazards, and chemical hazards from gases or hazardous liquids used or generated during treatment. The major hazards associated with most of the treatment methods, including thermal treatment, UV, US, BenRad, and Oxicide, were confined to the location of the equipment installation. None of the on-board treatment methods have the potential to threaten ship structural integrity in the manner of empty-refill ballast exchange. For biological de-oxygenation and ozone, ballast water is treated in the ballast tanks, so the hazard would encompass a larger area of the ship.

Most of the ballast water treatment methods, with the exception of biological de-oxygenation and ozone, require the ballast water to be pumped through treatment systems. This additional piping means that there is an additional risk for pipe breaks and leaks in areas of the ship where there was previously no risk of ballast water leaks. However, this is expected to be a minor risk as most additional pipe work would be in a very localized area.

Other hazards associated with ballast water treatment include the potential for a spill of hazardous material stored or being used within the treatment. The UV and BenRad treatment systems both use UV lamps that contain mercury or amalgamated mercury. The oxicide method uses nitric acid as an anolyte and requires sodium nitrate salt to be stored on board. All of these could result in damages if accidentally released.

With all methods, there is the potential to reduce risks through appropriate training and safety procedures. If these systems are installed on new ships additional safety features could be considered during ship design.

Environmental Effects

Environmental impact categories used to assess the effects of each of the ballast water treatment technologies tested in WP3 of the MARTOB project included:

- Direct Impact through Discharge to Receiving Water:
    - Discharge of water with altered quality with respect to the following parameter types:
        - Physical parameter
        - Metals
        - Nutrients/Oxygen Demand, Low D.O.
        - Biocide residuals

    - Discharge of surviving organisms
    - Discharge of solids (organisms and sediments)

- Other Environmental Impacts
    - Energy Consumption (treatment systems, additional pumping, filtration)
    - Potential for Spill of treatment chemicals
    - Materials use (both for consumables and for construction of treatment equipment)

Although some of the treatment methods will result in the discharge of ballast water with altered quality, none of the discharges will include substances that are identified as 'priority hazardous substances' (under the European Union's Water Framework Directive), or that have the potential to bio-accumulate. Ballast water quality will undergo the most changes with the biological oxygen removal method, which will produce a discharge that is low in dissolved oxygen and that has increased concentrations of nutrients and bacteria. The oxicide and BenRad method will both lower the dissolved oxygen concentration of the ballast water. Increased temperature of the ballast water discharge will occur after thermal treatment (10˚ C temperature increase) and ultrasound treatment (estimated range of 5-6 ˚ C temperature increase occurred during the laboratory scale tests). UV treatment has no effect on ballast water quality.

All methods will result in organic matter in the discharge in the form of dead organisms, but this will vary depending on filtration use, treatment type, and the concentration of organisms in the intake ballast water. The potential impact of this would be much less than if live non-indigenous species are released, but could be of minor concern in eutrophic waters. All but two of the methods would be operated using a filter as pre-treatment. Biological de-oxygenation and ultrasound treatment do not require the use of a filter. Methods using the filter as pre-treatment will need to discharge the filtered material to the receiving environment, which could cause some turbidity.

All treatment methods require the use of some energy, and this will result in environmental effects from fuel consumption and associated emissions. Energy use is lowest for biological oxygen removal and high temperature thermal treatment is the most energy intensive method (although the energy used is dependent on the selected treatment temperature and the temperature of the ballast water before treatment).

Stainless steel and titanium are the most commonly used materials for the treatment systems. Materials used for construction of the treatment equipment will be further refined in the next phase of the project when the treatment systems are constructed for full scale testing. It should then be possible to have more detailed information to assess life cycle impacts of the methods.

Economic Aspects

Installation of an on-board ballast water treatment system will lead to changes in a ships' capital costs, changes in annual operating costs, and possibly will lead to extra training and management costs and economic benefits or disadvantages. Generally, the cost calculation results highly depend on some basic data associated with shipping trade and ballast water treatment. This may include type and characteristic of the vessel, sailing and trading pattern, including aspects like route, distances, speed, sailing and harbour time, and number of voyages per year, volume of ballast water, number of ballast pumps and their capacities, type of fuel used, type of treatment and treatment capacity. Costs can be easily compared when they are calculated based on the same type of dependants mentioned above. The theoretical case study approach provided a consistent basis upon which to compare costs.

From the preliminary cost calculations it can be concluded that there are still some data gaps to be filled in. For some treatment methods the potential cost and cost factors are already quite transparent, for some other systems there is still a lot of data to be estimated. The differences are partly related to the status of development of the method. It is expected that during up-scaling of the systems and the large-scale trials more data will become available. In addition more research into tank cleaning costs, cost of corrosion control, certification cost, average wages of on-board personnel, total shipping cost to be able to calculate the impact of ballast water treatment on the total cost of shipping, needs to be done. During the next phase of the project the cost calculations will be further improved and refined.

The preliminary cost of treatment of ballast water on “the case study ship” varies considerably, ranging from €0.10/m^3 up to €2.34/m^3. Nevertheless, it should be kept in mind that not all data were available for the techniques, and some were preliminary.