Our Mission

The mission of ABS is to serve the public interest as well as the needs of our clients by promoting the security of life, property and the natural environment primarily through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities.

Quality & Environmental Policy

It is the policy of ABS to be responsive to the individual and collective needs of our clients as well as those of the public at large, to provide quality services in support of our mission, and to provide our services consistent with international standards developed to avoid, reduce or control pollution to the environment.

All of our client commitments, supporting actions, and services delivered must be recognized as expressions of Quality. We pledge to monitor our performance as an on-going activity and to strive for continuous improvement.

We commit to operate consistent with applicable environmental legislation and regulations and to provide a framework for establishing and reviewing environmental objectives and targets.
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Disclaimer
The development and approval of ballast water treatment systems is a dynamic process. The information contained in this ABS Advisory Notice should not be construed as being all encompassing and readers are urged to contact ABS or review the latest IMO information available to determine the extent to which the status of the various systems included here may have changed and if other systems have been proposed for review and approval.
The ballast water and sediments carried by ships have been identified as a major pathway for the transport of harmful invasive aquatic organisms and pathogens. Ships often take on ballast water in one port and carry such ballast to other ports where it is discharged. The ballast water and sediments contain living organisms which, despite the harsh conditions in the ballast tanks and piping systems, survive to compete with native species in the port of discharge. If the non-native organisms have few natural predators or other natural controls they may become invasive and change the local ecosystems, sometimes dramatically.

The direct economic impact of aquatic invasive species, as well as the potential long term damage to the health of the local marine environment and the people who depend on that environment has been well documented. International, national and regional regulations have been implemented to control the transport of the aquatic organisms. The current efforts rely on ballast water management (BWM) practices, including ballast exchange, and other measures aimed at preventing or minimizing the uptake and discharge of contaminated water or sediment when ballasting or deballasting. These methods may not be completely effective in preventing invasive species and furthermore are often not required if the safety of the vessel would be at risk during the exchange. Systems that treat ballast water to remove or kill organisms are not only potentially more reliable but are designed and installed to achieve measurable efficacy levels while protecting vessel safety.

This ABS Advisory has been produced to summarize the current state of ballast water treatment regulations and available technologies in order to provide useful guidance to shipowners, operators, and builders as they make decisions about suitable treatment options.

This Advisory contains five sections:

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Section 1: Regulatory Developments

International Regulatory Status (IMO)

In 2004, the IMO adopted the International Convention for the Control and Management of Ships’ Ballast Water and Sediments. The Convention calls for ships to conduct a ballast water exchange or to meet a concentration-based ballast water discharge standard in accordance with a gradually implemented schedule linked to the ship’s build date and the amount of ballast carried on board the ship.

Acceptance of the Convention has been slow. Entry into force will occur 12 months after ratification by 30 States representing 35 percent of world merchant shipping gross tonnage. The current information on ratification is included in Table 1. Because of the slow pace of adoption, the implementation deadlines written into the Convention have become obsolete before they could become mandatory. This has required adjustments to the implementation schedule. This uncertain regulatory schedule makes it all the more difficult for owners, builders and manufacturers to plan for the necessary equipment.

Until such time as the Convention enters into force and the implementation schedule becomes binding globally, actions to address the issue of invasive species are increasingly occurring at national, regional and local levels. More than a dozen individual nations, in addition to regions as diverse as northwest Europe, the Great Lakes, ROPME Sea Area and Antarctica, have introduced specific regulations addressing the discharge of ballast in their waters. Further complicating the issue, government authorities such as those in California, Michigan, New York and others within the US, and the State of Victoria in Australia, have introduced local ballast water management requirements. A small number of these jurisdictions may prohibit the discharge of ballast water entirely (e.g. Panama within the Panama Canal), require chlorination (e.g. Buenos Aires), or restrict in-port discharge to an approved onshore reception facility.

Owners are encouraged to contact their relevant flag State, port agents or shipowner association for the latest specific information on national or regional requirements as new and additional requirements are being mandated. The following sections provide information on the requirements for treatment as outlined in the IMO Convention. A few significant regional developments are also provided.

Applicability of the IMO BWM Convention

The 2004 IMO BWM Convention applies to all vessel types operating in the aquatic environment which are designed to carry ballast water and are entitled to fly the flag of a Party to the Convention. This includes submersibles, floating craft and platforms including floating storage units (FSUs) and floating production storage and offloading units (FPSOs), although the applicable requirements vary. Refer to Table 1 for a list of Parties to the Convention.

IMO BWM Convention Treatment Standards

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.

Ballast water exchange is founded on the principle that organisms and pathogens contained in ballast water taken on board from coastal waters will not survive when discharged into deep oceans or open seas, as these waters have different temperatures, salinity and chemical composition. Similarly the deep ocean waters or open seas, when compared

<table>
<thead>
<tr>
<th>States</th>
<th>% Tonnage</th>
<th>Parties to the Convention:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needed: 30</td>
<td>Needed: 35%</td>
<td>Albania, Antigua and Barbuda, Barbados, Brazil, Canada, Cook Islands, Croatia, Egypt, France, Iran, Kenya, Kiribati, Republic of Korea, Liberia, Malaysia, Maldives, Marshall Islands, Mexico, Netherlands, Nigeria, Norway, Saint Kitts and Nevis, Sierra Leone, South Africa, Spain, Sweden, Syrian Arab Republic and Tuvalu.</td>
</tr>
<tr>
<td>Currently: 28</td>
<td>Currently: 25.43%</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Status of Ratification of the IMO BWM Convention (As of 15 April 2011)
to the coastal waters, contain fewer organisms and pathogens and those that do exist are less likely to adapt to the new coastal or freshwater environment. Therefore the probability of organism and pathogen transfer through ballast water is significantly reduced.

Ships performing ballast water exchange are required to do so with an efficiency of at least 95 percent volumetric exchange. Acceptable methods for ballast water exchange are the Sequential Method, the Flow-through Method and the Dilution Method.

Noting that ballast water exchange presents significant operational concerns and challenges, and that it may not provide a totally effective solution to reduce the spread of unwanted aquatic organisms and pathogens from ships’ ballast water over time, the Convention requires an upgrade to the installation of ballast water treatment systems in accordance with a specified schedule.

Regulation D-2 defines the performance standard for the ballast water treatment system. This criterion is in the form of specific limits on aquatic life in the ballast discharge:

Ships conducting ballast water management in accordance with this regulation shall discharge:

- Less than 10 viable organism per m³ ≥ 50µ in minimum dimension, and
- Less than 10 viable organisms per ml < 50µ and ≥10µ in minimum dimension, and
- Less than the following concentrations of indicator microbes:
  - Toxicognic Vibrio cholera less than 1 colony forming unit (cfu) per 100 ml, or less than 1 cfu per 1 gram zooplankton samples
  - Escherichia coli less than 250 cfu per 100 ml
  - Intestinal Enterococci less than 100 cfu per 100 ml

The D-2 standard is the metric used to measure the efficacy of the treatment system and it applies to the system as installed on board and used in actual operations. All treatment systems must be type approved by an Administration under a robust protocol which requires that they satisfy this standard in full scale operations. In any port or offshore terminal, an officer authorized by a Party to the Convention may board a vessel to which the Convention applies and test the ballast water discharge for compliance by taking samples.

### IMO BWM Convention Compliance Timeframe

Table 2 indicates the implementation schedule as detailed in Regulation B-3 of the International Convention for the Control and Management of Ships’ Ballast Water and Sediments, 2004 as revised by IMO Resolutions A.1005(25) and MEPC.188(60). These resolutions were adopted as a result of the review of the entry into force provisions and the development and availability of type approved ballast water treatment technologies.

<table>
<thead>
<tr>
<th>Ballast Cqty (m³)</th>
<th>Build Date</th>
<th>*First Intermediate or Renewal Survey, whichever occurs first, after the anniversary date of delivery in the respective year</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1,500</td>
<td>&lt; 2009</td>
<td>D-1 or D-2</td>
</tr>
<tr>
<td></td>
<td>in 2009</td>
<td>Note: D-1; D-2 by 2nd Annual but not beyond 31 Dec. 2011 or EIF, whichever is later</td>
</tr>
<tr>
<td></td>
<td>&gt; 2009</td>
<td>D-2</td>
</tr>
<tr>
<td>≥ 1,500 or ≤ 5,000</td>
<td>&lt; 2009</td>
<td>D-1 or D-2</td>
</tr>
<tr>
<td></td>
<td>in 2009</td>
<td>Note: D-1; D-2 by 2nd Annual but not beyond 31 Dec. 2011 or EIF, whichever is later</td>
</tr>
<tr>
<td></td>
<td>&gt; 2009</td>
<td>D-2</td>
</tr>
<tr>
<td>≥ 5,000</td>
<td>&lt; 2012</td>
<td>D-1 or D-2</td>
</tr>
<tr>
<td></td>
<td>≥ 2012</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note: EIF = Entry into force
It was noted at the 59th session of the IMO Marine Environmental Protection Committee that there are a sufficient number of type approved ballast water treatment technologies available for ships constructed in or after 2009 that have a ballast water capacity of less than 5,000 m³. Resolution MEPC.188(60) conveys the committee’s position that while the requirements of the regulation cannot be enforced before the entry into force of the BWM Convention, it should be clearly understood that the ballast water management systems installed on ships constructed in 2010 must comply with the ballast water performance standard once the BWM Convention is ratified. At MEPC 61, the Committee agreed that a new review of ballast water treatment technologies, focused on larger ships with a ballast water capacity of 5,000 m³ or more (in particular those with higher flow rate) would be necessary when it reconvened at MEPC 62 in July 2011.

Additional clarification regarding the application dates for ships constructed before 2009, Regulation B-3.1 of the BWM Convention, can be found in IMO BWM.2/Circ.29. This circular revokes BWM.2/Circ.19 and builds on the experience gained during the implementation of Regulations 20 and 21 of MARPOL Annex I. IMO BWM.2/Circ.29 confirms that the “anniversary date of delivery of the ship in the year of compliance” specified in Regulation B-3.2, refers to years 2014 and 2016 indicated in Regulation B-3.1.

Consequently, ships with a ballast water capacity between 1,500 and 5,000 m³ inclusive are required to comply with the D-2 standard not later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of delivery of the ship in 2014 under Regulation B-3.1.1. Ships with a ballast water capacity of less than 1,500 m³ or greater than 5,000 m³ are required to comply with the D-2 standard not later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of the delivery of the ship in 2016 under Regulation B-3.1.2.

The following examples are instructive in how to interpret Table 2.

- A ship with a ballast water capacity less than 5,000 m³ constructed in 2009 will not be required to comply with D-2 standard until its second annual survey but not later than 31 December 2011. (Res.A.1005(25))

- A ship with a ballast water capacity of less than 5,000 m³ constructed after 2009 must be equipped with a type approved ballast water treatment system that meets the D-2 standard upon delivery or EIF, whichever is later. (Res.MEPC.188(60))

- A ship with a ballast water capacity of greater than 5,000 m³ constructed before 2012 is to be equipped with a type approved ballast water treatment system that meets the D-2 standard not later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of delivery of the ship in 2016. (BWM.2/Circ.29)

Owners and operators are encouraged to consult with representatives from the local ABS technical offices for additional clarification once the entry into force criteria have been satisfied.

**IMO Activity Related to the 2004 Convention**

At MEPC 61, the committee approved the framework for determining when a basic approval granted to one ballast water management system may be applied to another system that uses the same active substances or preparation (BWM.2/Circ.27). In addition, guidance for Administrations on the type approval process for ballast water management systems in accordance with the G8 guideline was approved (BWM.2/Circ.28).

IMO invited member governments and observers to propose practical solutions to the challenges of the BWM Convention, in relation to some special types of ships, in particular seagoing unmanned barges, semisubmersibles and heavy lift crane vessels. The committee urged member States to apply, as soon as possible, the provisions of Resolution MEPC.188(60), which encourages member governments to install ballast water treatment systems on new ships in accordance with the application dates contained in the BWM Convention.
IMO Guidelines Available

Since the adoption of the Convention, IMO has been working to develop a series of guidelines that further clarify and expand upon the requirements put forward in the Convention. All 14 of the planned guidelines have been completed and are available from IMO. A list of the guidelines supporting the Ballast Water Convention is as follows:

G1  Sediment Reception Facilities  MEPC.152(55)
G2  Guidelines for Ballast Water Sampling  MEPC.173(58)
G3  BW Equivalent Compliance  MEPC.123(53)
G4  BWM and the Development of BWM Plans  MEPC.127(53)
G5  BW Reception Facilities  MEPC.153(55)
G6  BW Exchange – Operational  MEPC.124(53)
G7  Risk Assessment under Regulation 4-A of the BWM Convention  MEPC.162(56)
G8  Guidelines for Approval of BW Management Systems  MEPC.125(53)
             Rev. MEPC.174(58)
G9  Approval of BW Systems that make use of Active Substances  MEPC.126(53)
             Revision MEPC.169(57)
G10  Approval and Oversight of Prototype BW Treatment Programs  MEPC.140(54)
G11  Guidelines for BW Exchange Design and Construction Standard  MEPC.149(55)
G12  Design and Construction to Facilitate Sediment Control on Ships  MEPC.150(55)
G13  Guidelines for Additional Measures Regarding BWM Including Emergency Situations  MEPC161(56)
G14  Guidelines on Designation of Areas for BWE  MEPC.151(55)

Note: BW = Ballast Water
BWM = Ballast Water Management
BWE = Ballast Water Exchange

Of special interest to owners and builders are the requirements for ballast water sampling contained in the G2 guideline as it impacts ballast system design and operation. The objective of the G2 guideline is to provide all parties, including Port State Control officers, with practical and technical guidance on ballast water sampling and analysis for determining if the ship is in compliance with the Ballast Water Management Convention.

It is important to note that the G2 guideline discusses general sampling procedures and does not address the legal requirements as the legislative procedures and requirements for enforcement action based on biological testing are significantly different from country to country. The guideline includes the following issues related to operation of the treatment system:

- It was recognized by IMO that the sampling must be simple, rapid and applicable at the point of ballast discharge and safe to the ship and crew. Time needed for the analysis of the collected samples shall not be used as a basis for unduly delaying the operation, departure or movement of the vessel.
- The sample is to be taken from the discharge line, as near to the point of discharge as possible, during discharge. Note that the G8 guideline also calls for sampling points; however, the points in the G2 guideline are not just for testing during the type approval but also for in-service testing. Tank sampling for those systems which use a treatment system is not preferred as the scientific trials have shown that these samples may not provide accurate estimates of the organism concentration. An exception to this guidance may be when the ballast tanks are emptied through direct overboard discharge valves such as in upper wing tanks.
- Isokinetic sampling ports are recommended so that the sample water is collected at the same flow rate as the ballast water in the discharge line, since this will lessen the likelihood of there being a difference in the organism and particulate matter concentrations.
- Initial and indicative analysis to establish whether a ship is complying with the D-2 standard may be undertaken and, if further doubt exists, the samples are to undergo a more stringent analysis to establish if the D-2 standard is being met.

The use of monitoring and in line recording devices of physical and/or chemical indicators are
Ten of the Most Unwanted

Marine plants, animals and microbes are being carried around the world attached to the hulls of ships and in ships’ ballast water. When discharged into new environments, they may become invaders and seriously disrupt the native ecology and economy. Introduced pathogens may cause diseases and death in humans.

It is not certain how regional measures that are more stringent than IMO requirements would be viewed under this guideline. This is potentially very important for those vessels intending to transit to regions with local requirements, for example US waters. Guidelines G8 to G10 address the approval of ballast water treatment systems.

Overview of Some Regional, National & Local Regulations

United States/USCG

The United States first passed ballast water legislation in 1990 as the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA). This law established the US Coast Guard’s (USCG) regulatory jurisdiction over ballast water management, mandated a regional ballast water management program for the Great Lakes and called for studies to document the need for a national ballast water management program.

To implement the NANPCA the USCG published a final rule in the Federal Register on 8 April...
1993 wherein 33 CFR Part 151, Subpart C, the mandatory ballast water management requirements for ships entering the waters of the Great Lakes after operating outside of the US Exclusive Economic Zone were established. These regulations were extended to portions of the Hudson River in 1994. In 1996, the US Congress enacted the National Invasive Species Act (NISA). This charged the USCG with establishing a voluntary ballast water management program for all other US ports and required vessels to submit ballast water management reports.

In addition, this Act directed the USCG to submit a report to the US Congress on the effectiveness of the voluntary program and to make the program mandatory if the rate of compliance with the mandatory guidelines was determined to be inadequate. In May 1999 the USCG published an interim rule in the Federal Register entitled “Implementation of the National Invasive Species Act of 1996”. This interim rule created the mandatory ballast water reporting and recordkeeping requirements and prompted voluntary BWMP practices (including ballast water exchange) for all vessels entering all waters of the United States after operating outside the exclusive economic zone.

In November 2001, the interim rule was amended and published as a final rule. On 3 June 2002, the USCG submitted the first ballast water management report to Congress wherein it was concluded that compliance with the mandatory reporting requirements was insufficient to allow for an accurate assessment of the voluntary ballast water management program. This report to Congress also stated that it is the intention of the Secretary of Homeland Security to have the USCG take additional actions to reduce the inflow of aquatic nuisance species. In June 2004, the voluntary guidelines of 33 CFR 151, Subpart D were made mandatory for all vessels equipped with ballast water tanks.

There have been a number of bills introduced in the US Congress that propose a ballast discharge standard. None have yet become law. However, the USCG released a notice of proposed rulemaking (FR 44633 28 August 2009). The proposed rulemaking and regulatory analysis includes an assessment of the economic impact of treatment standards between the IMO D-2 levels and levels up to 1,000 times more stringent (see Table 3).

The proposed treatment regulation calls for a two-phase implementation schedule. The Phase 1 standard is the same as the IMO D-2 and the implementation schedule is similar to the IMO schedule. Existing ships (those built prior to 1 January 2012) with ballast water capacity of between 1,500 and 5,000 m³ will be required to meet this standard by their first drydocking after 1 January 2014. Ships with ballast water capacity of less than 1,500 m³ or greater than 5,000 m³ must meet the standard by their first drydocking after 1 January 2016. New vessels (those with build dates on or after 1 January 2012) will be required to meet it at delivery.

Phase 2 discharge requirements must be met by new ships with a build date on or after 1 January 2016. For ships with a build date before 1 January 2016, the compliance date is the first drydocking
after 1 January 2016 or five years after a Phase 1 system was installed, whichever is later. A ‘practicability review’ by the USCG is also proposed for 2013 to evaluate whether the technology to achieve the Phase 2 standard is available in order to confirm the future phase entry into force dates. While the standards and schedule generally apply to all commercial ships discharging ballast in US waters, there is a notable exemption for crude oil tankers engaged in coastwise trade. The issuance of the final USCG regulations originally scheduled for December 2010 has been delayed.

Ballast discharges in US ports are further regulated by the Vessel General Permit (VGP) for the National Pollution Discharge Elimination System (NPDES) program under the Clean Water Act (CWA). Previously exempted from the NPDES program, ballast water discharges in port must now be documented and the vessel must follow federal regulation aimed at controlling discharge of harmful or invasive elements within the ballast water. Treatment is not explicitly required and there is no treatment standard in US Federal regulatory regime in the current VGP. However, the CWA allows each individual State to add specific provisions, including performance standards, to the VGP. A treatment system that uses active substances (chemicals or biological agents) would be subject to scrutiny under the Clean Water Act.

Other US States
Michigan, Minnesota and Wisconsin have specific state laws and regulations establishing ballast water discharge standards or management programs. In addition, a number of other US states have included ballast water discharge standards as part of their Clean Water Act certification with the VGP.

In February 2011, the state of New York’s Water Quality Certification Agency issued a letter granting an extension of the implementation date for ‘Condition 2’ (which is 100 times more stringent then the IMO’s D-2 Regulation) from 1 January 2012 until midnight 13 August 2013.

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### Table 4: Discharge Standards in Current California Law

<table>
<thead>
<tr>
<th>Organism Size</th>
<th>California Law</th>
<th>IMO Regulation D-2</th>
<th>US Proposed Law Phase 2 Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 50µm in min. dimension</td>
<td>No detectable living organisms</td>
<td>&lt; 10 viable organisms/m³</td>
<td>&lt; 1 viable organisms/100 m³</td>
</tr>
<tr>
<td>&lt; 50µm and ≥ 10µm in min. dimension</td>
<td>&lt; 0.01 living organisms per ml</td>
<td>&lt; 10 viable organisms/ml</td>
<td>&lt; 1 viable organisms/100 ml</td>
</tr>
<tr>
<td>&lt; 10µm in min. dimension</td>
<td>&lt; 10⁵ bacteria/100 ml &lt; 10⁴ viruses/100 ml</td>
<td>no limit</td>
<td>&lt; 10⁵ bacteria/100 ml &lt; 10⁴ viruses/100 ml</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>&lt; 126 cfu/100 ml</td>
<td>&lt; 250 cfu/100 ml</td>
<td>&lt; 126 cfu/100 ml</td>
</tr>
<tr>
<td>Intestinal enterococci</td>
<td>&lt; 33 cfu/100 ml</td>
<td>&lt; 100 cfu/100 ml</td>
<td>&lt; 33 cfu/100 ml</td>
</tr>
<tr>
<td>Toxigenic Vibrio cholerae</td>
<td>&lt; 1 cfu/100 ml or &lt; 1 cfu/gram wet weight zoological samples</td>
<td>&lt; 1 cfu/100 ml or &lt; 1 cfu/gram wet weight zooplankton samples</td>
<td>&lt; 1 cfu/100 ml</td>
</tr>
</tbody>
</table>

As shown in Table 4, the California standards are much more stringent than the IMO standards and similar (but not identical) to the Phase 2 standard recently proposed by the USCG (shown in Table 3). The California law includes explicit guidelines for sampling points and methods. In addition, California law currently sets a final discharge implementation date of 1 January 2020 that specifies zero detectable living organisms for all size ranges in the ballast discharge stream.

### California
California’s Marine Invasive Species Act (2003) established the Marine Invasive Species Program and directed a state agency to develop performance standards for ballast water discharge. In 2006, the State passed the Coastal Ecosystems Protection Act (SB497) which incorporated the recommended standards and made them mandatory. The implementation schedule was initially set to match the IMO schedule. In 2008, a review required by the law of available treatment technologies recommended that the implementation date for new ships be delayed one year to 2010.

As shown in Table 4, the California standards are much more stringent than the IMO standards and similar (but not identical) to the Phase 2 standard recently proposed by the USCG (shown in Table 3). The California law includes explicit guidelines for sampling points and methods. In addition, California law currently sets a final discharge implementation date of 1 January 2020 that specifies zero detectable living organisms for all size ranges in the ballast discharge stream.

Michigan, Minnesota and Wisconsin have specific state laws and regulations establishing ballast water discharge standards or management programs. In addition, a number of other US states have included ballast water discharge standards as part of their Clean Water Act certification with the VGP.

In February 2011, the state of New York’s Water Quality Certification Agency issued a letter granting an extension of the implementation date for ‘Condition 2’ (which is 100 times more stringent then the IMO’s D-2 Regulation) from 1 January 2012 until midnight 13 August 2013.
Section 2

BWT Technologies

This section of the Advisory Notice provides an explanation of treatment technologies currently being developed, the regulatory approval process certifying vendor-supplied equipment as compliant with the regulation, and a list of available systems currently on the market as of the date of publication of this document.

Overview of Treatment Technologies

IMO defines ballast water treatment equipment as:

“...the equipment which mechanically, physically, chemically or biologically processes either singularly or in combination to remove, render harmless or avoid the uptake or discharge of harmful organisms or pathogens. Ballast water treatment equipment may operate at the uptake or discharge of ballast water, during the voyage, or at a combination of these events.”

Types of Treatment Technologies

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. These groups and the more promising technologies related to each are shown in Figure 1 and described briefly in the following text.

Mechanical Systems

- Filtration – sediment and particles are removed with disk and screen filters during ballast intake. They are often self-cleaning with a back-flushing cycle. The waste stream is directed overboard back to the water source. These filtration systems create pressure drops and a reduced flow rate due to resistance in the filter elements and the self-cleaning procedures.
- Cyclonic separation – solid particles are separated from the water due to centrifugal forces. Only those particles with a specific gravity greater than that of water can be separated.
- Electro-mechanical separation – a flocculent is injected that attaches to organisms and sediment. Magnetic separation and filtration is used to remove the solid particles.

Physical Disinfection

- Ultraviolet light – UV radiation is used to attack and break down the cell membrane killing the organism outright or destroying its ability to reproduce. The effectiveness depends on the turbidity of the ballast water (i.e. the concentration of sediments) as this could limit the transmission of the UV radiation. UV lights are required to be maintained and power consumption needs to be considered.
- Cavitation/ultrasounds – venturi pipes or slit plates are used to generate cavitation bubbles and this high energy bubble creation and collapse results in hydrodynamic forces and ultrasonic oscillations, or high frequency noise, which disrupts the cell walls of organisms effectively killing them.

Chemical Treatment

- Disinfecting Biocides
- Electrolytic Chlorination

Figure 1: Treatment Technology Types
• De-oxygenation – various methods are used to remove the dissolved oxygen in the ballast water and replace it with inactive gases, such as nitrogen or other inert gas. Removing the oxygen not only kills the aerobic organisms but it can also have benefits for corrosion prevention provided that the oxygen content is maintained at the correct levels. De-oxygenation can require a prolonged period in order to render the organisms and pathogens harmless to the receiving waters.

Chemical Treatment
• Disinfecting biocides – pre-prepared or packaged disinfectants designed to be dosed into the ballast flow and kill the living organisms by chemical poisoning or oxidation. Typical biocides include chlorine, chloride ions, chlorine dioxide, sodium hypochlorite and ozone. Residual biocides in the ballast water must meet ballast discharge standards which may require neutralization techniques.
• Electrolytic chlorination – electrical current is applied directly to the ballast water flow in an electrolytic chamber, generating free chlorine, sodium hypochlorite and hydroxyl radicals, causing electrochemical oxidation through the creation of ozone and hydrogen peroxide. This method is limited in effectiveness to seawater having a certain level of dissolved salt and could also create unwanted residuals.

Types of chemical treatments include Active Substances or Preparations. The official definitions given in the BWM Convention are as follows:
• Active substance – a substance or organism, including a virus or a fungus that has a general or specific action on or against harmful aquatic organisms and pathogens.
• Preparation – any commercial formulation containing one or more active substances including any additives. This term also includes any active substances generated on board for the purpose of ballast water treatment and any relevant chemicals formed in the ballast water treatment system that make use of active substances to comply with the BWM Convention.

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 ballast. UV radiation is also used during deballasting. These systems are sized for the maximum flow rate in the ballast system. Conversely chemical biocides and de-oxygenation 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 treatment system. To overcome the limitations of a particular technology many proposed treatment systems are based on a combination of two or more technologies. Although there are approved chemical disinfection only treatments, these are often combined with some form of pre-treatment to make them more effective for certain vessel or ballast conditions.

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.
Treatment System Approval by IMO & Member States

IMO Approval Regime

Regulation D-3 of the BWM Convention requires that ballast water treatment systems be approved by the flag State Administration and for those treatment systems which make use of active substances or preparations, by the IMO as well. It is important to note that the Convention requires that discharges of ballast water from ships must meet the D-2 standard on an ongoing basis.

Type approval of a ballast water treatment system should not be considered as an indication that a given system will work on all vessels in all situations. Even after installing a type approved system, the owner/operator is still responsible for compliance of the discharge throughout the vessel’s life.

To achieve consistency in the approval process, IMO has prepared several guidelines.

G8 Guidelines for Approval of Ballast Water Management Systems
Resolution MEPC.174(58)

G9 Procedure for Approval of Ballast Water Management Systems that Make Use of Active Substances
Resolution MEPC.169(57)

These guidelines outline the approval framework and a uniform manner of testing, analysis of samples and evaluation of results. Together, the G8 and G9 guidelines address the approval required under Regulation D-3 of the Convention for those ballast water treatment systems that make use of active substances. G8 addresses the suitability and efficacy of the system. In addition, where it can be reasonably concluded that the treatment process could result in changes to the chemical composition of the treated water such that adverse impacts to the receiving waters might occur upon discharge, additional testing will be required by the G8 guideline. G9 addresses the acceptability of any active substances and preparations for use in ballast water treatment systems concerning ship safety, human health and the aquatic environment. The G9 guideline is provided as a safeguard for the sustainable use of active substances and preparations.

To encourage the development of new ballast water treatment technologies, the Convention includes an allowance for short term approval of a treatment system that undergoes prototype testing according to G10 guideline. For any ship
that participates in a prototype testing program, the requirements of Regulation D-2 shall not apply until five years after the date the equipment was installed or five years after the date on which the ship would otherwise be required to comply with D-2, whichever is later.

The G8/G9 approval process is a robust and lengthy process requiring approximately one year to complete. It includes the following:

- Documentation review and approval of the design and construction of the system and an assessment to determine if there are any fundamental problems that might constrain the ability of the system to manage ballast water or operate safely.
- Successful compliance with environmental testing by an approved laboratory of all system components. This testing is to include specified limits of vibration, temperature, humidity, fluctuations in power supply, inclination and, if applicable, protection from green water impact.
- Land-based testing to confirm that the system can meet the D-2 standard for a range of water conditions (fresh, brackish and sea). The land-based approval testing is intended to provide replicability and comparability to other treatment systems. Any limitations imposed by the treatment system on the testing procedure should be noted and evaluated by the Administration in its consideration for type approval. In some situations, the land-based testing can be done on scaled-down equipment.
- Shipboard testing of a complete, full scale system throughout a full ballast cycle (uptake, storage, treatment, and discharge). At least three consecutive successful test cycles that comply with Regulation D-2 are required over a period not less than six months.

Systems with active substances or preparations must undergo the additional approval process contained in the IMO G9 guideline to verify that the potential hazardous properties of the active substance or preparations or relevant chemicals formed in treated ballast water do not create any unreasonable risk to the ship and personnel and that the ballast water is no longer toxic. Toxicity testing is needed to confirm that the active substance or preparation used does not cause conditions which have the potential of harming the receiving environment or human health.

The additional approval required under the G9 guideline uses a two-tier methodology consisting of a basic and final approval.

- Basic approval confirms that, based on the information available, there are no unacceptable adverse effects, nor a potential for unreasonable risk to the environment, human health, property or resources. It includes screening for persistency, bioaccumulation and toxicity. Testing is conducted in a laboratory under conditions simulating ballast water discharge following treatment.
- Final approval confirms the previous evaluations of risks to the ship, crew and the environment including the storage, handling and application of active substances or preparations, remain valid and concerns expressed during the basic approval process have been addressed, as well as the residual toxicity of the discharge conforms to the evaluation undertaken for basic approval. In addition, a risk evaluation is performed at the final approval to qualitatively account for the cumulative effects that may occur due to the nature of shipping and port operations.

Both steps involve not only review by the Administration, but are also subject to a direct and complete review by a special technical group set up within IMO. This technical group is the Group of Experts on the Scientific Aspects of Marine Environmental Protection – Ballast Water Working Group (GESAMP-BWWG). The GESAMP-BWWG
Once the technical review and testing are completed to the satisfaction of the Administration and the Administration is satisfied that the quality assurance program employed by the manufacturer will mean that the equipment can be produced consistently to the required specification, a Type Approval Certificate may be issued. When a type approved ballast water treatment system is installed on board a vessel, an installation survey is conducted to confirm that the system has been installed as designed, is ready for operation, and conforms to the Type Approval Certificate. Upon successful completion of the installation survey, a BWM Certificate may be issued as required by the Convention.

Verifying Equipment Approval

Any system which is being considered for installation on board a ship should have a valid Type Approval Certificate in the proper form and signed by the Administration. This certificate should:

- Identify the type and model of the system, related equipment assembly drawings and model specification numbers;
- Include a reference to the full performance test protocol on which the approval is based and be accompanied by a copy of the original test results;
- State the specific application for which the treatment system is approved, e.g. for specific ballast water capacities, flow rates, salinity or temperature regimes, or other limiting conditions or circumstances as appropriate.

Table 5: Ballast Water Treatment System Approval Process Overview

<table>
<thead>
<tr>
<th>Approval Process for Manufacturer</th>
<th>Ship-Specific Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Steps in Approval Process</td>
<td></td>
</tr>
<tr>
<td>Documentation Review &amp; Approval</td>
<td>Administration</td>
</tr>
<tr>
<td>Basic Approval for Active Substances (G9)</td>
<td>GESAMP-BWWG, IMO</td>
</tr>
<tr>
<td>System Approval Land &amp; Shipboard Testing</td>
<td>Administration</td>
</tr>
<tr>
<td>Final Approval for Active Substances (G9)</td>
<td>GESAMP-BWWG, IMO</td>
</tr>
<tr>
<td>Type Approval Certificate</td>
<td>Administration</td>
</tr>
<tr>
<td>Installation Survey</td>
<td>Administration</td>
</tr>
</tbody>
</table>

makes a recommendation to the IMO MEPC which, on the basis of the GESAMP-BWWG’s report, will confer approval on a treatment system that uses active substances.

The overall approval process is summarized in Table 5. Shaded parts (G9) can be omitted for systems not using active substances (e.g., de-oxygenation or ultrasonic). A more complete flow chart of the approval process is shown in Figure 2.
Figure 2: Flow Chart of Ballast Water Management System Approval

BWM System (treatment, control & monitoring)

Yes

Documentation review & approval by a government

No

BWMS includes active substances

Yes

Manufacturer tests found satisfactory by a government

Yes

Basic approval or active substances granted by IMO

No

No

No

Type Approval

G(8)

Prototype Testing

G(10)

BMW system test protocol options

Yes

Results may be used

No

Land-based testing to D-2 standard is satisfactory

Yes

Shipboard testing to D-2 standard is satisfactory

Yes

All BW discharged during test period meets D-2 standard

No

BWMS includes active substances

Yes

Final approval for active substances granted by IMO

Yes

Government grants type approval of BWMS

Yes

Type Approved BWMS can be installed on board any ship

No

No

No

No

BWMS adversely changes chemical composition of treated water

No

Government grants type approval of BWMS

No

Ship issued BWM Certificate after functional test of BWMS

No
Treatment System Approval Status
The following tables summarize the current basic, final and type approval status of record. Systems that have received final and/or type approval are described more fully in the Appendix of this Advisory.

Table 6: BWM System Approvals as of MEPC 61
Approval Status of BWM Systems using Active Substances (G9)

<table>
<thead>
<tr>
<th>System Name</th>
<th>Proposed By</th>
<th>Approval Type</th>
<th>Approved By</th>
</tr>
</thead>
<tbody>
<tr>
<td>PureBallast System</td>
<td>Norway</td>
<td>Basic &amp; Final</td>
<td>MEPC 56</td>
</tr>
<tr>
<td>SEDNA-Ocean BWMS System using PERACLEAN Ocean System</td>
<td>Germany</td>
<td>Basic / Final</td>
<td>MEPC 54 / MEPC 57</td>
</tr>
<tr>
<td>OceanSaver BWMS System</td>
<td>Norway</td>
<td>Basic / Final</td>
<td>MEPC 57 / MEPC 58</td>
</tr>
<tr>
<td>Electro-Cleen System (Electrolytic Disinfection)</td>
<td>Korea</td>
<td>Basic / Final</td>
<td>MEPC 54 / MEPC 58</td>
</tr>
<tr>
<td>RWO BWMS (CleanBallast)</td>
<td>Germany</td>
<td>Basic / Final</td>
<td>MEPC 55 / MEPC 59</td>
</tr>
<tr>
<td>NK-03 Blue Ballast System (Ozone)</td>
<td>Korea</td>
<td>Basic / Final</td>
<td>MEPC 56 / MEPC 59</td>
</tr>
<tr>
<td>Hitachi BW Purification System (ClearBallast)</td>
<td>Japan</td>
<td>Basic / Final</td>
<td>MEPC 57 / MEPC 59</td>
</tr>
<tr>
<td>Hamworthy Sedinox BWMS</td>
<td>Netherlands</td>
<td>Basic / Final</td>
<td>MEPC 58 / MEPC 59</td>
</tr>
<tr>
<td>Resource Ballast Technologies System (Unitor)</td>
<td>South Africa</td>
<td>Basic / Final</td>
<td>MEPC 57 / MEPC 60</td>
</tr>
<tr>
<td>GloEn-Patrol System</td>
<td>Korea</td>
<td>Basic / Final</td>
<td>MEPC 57 / MEPC 60</td>
</tr>
<tr>
<td>JFE BallastAce (in cooperation with TG)</td>
<td>Japan</td>
<td>Basic / Final</td>
<td>MEPC 58 / MEPC 60</td>
</tr>
<tr>
<td>HHI BWMS (EcoBallast)</td>
<td>Republic of Korea</td>
<td>Basic / Final</td>
<td>MEPC 59 / MEPC 60</td>
</tr>
<tr>
<td>FineBallast OZ</td>
<td>Japan</td>
<td>Basic / Final</td>
<td>MEPC 55 / MEPC 61</td>
</tr>
<tr>
<td>EcoChlor BW Treatment System</td>
<td>Germany</td>
<td>Basic / Final</td>
<td>MEPC 58 / MEPC 61</td>
</tr>
<tr>
<td>ARA Ballast BWMS</td>
<td>Republic of Korea</td>
<td>Basic / Final</td>
<td>MEPC 60 / MEPC 61</td>
</tr>
<tr>
<td>BalClor BWMS</td>
<td>China</td>
<td>Basic / Final</td>
<td>MEPC 60 / MEPC 61</td>
</tr>
<tr>
<td>OceanGuard BWMS</td>
<td>Norway</td>
<td>Basic / Final</td>
<td>MEPC 60 / MEPC 61</td>
</tr>
<tr>
<td>Severn Trent DeNora BWMS (BalPure)</td>
<td>Germany</td>
<td>Basic / Final</td>
<td>MEPC 60 / MEPC 61</td>
</tr>
<tr>
<td>AquaTriComb BW Treatment System</td>
<td>Germany</td>
<td>Basic</td>
<td>MEPC 59</td>
</tr>
<tr>
<td>Blue Ocean Shield BWMS</td>
<td>China</td>
<td>Basic</td>
<td>MEPC 59</td>
</tr>
<tr>
<td>SiCURE BWMS</td>
<td>Germany</td>
<td>Basic</td>
<td>MEPC 60</td>
</tr>
<tr>
<td>DESMI Ocean Guard BWMS</td>
<td>Denmark</td>
<td>Basic</td>
<td>MEPC 60</td>
</tr>
<tr>
<td>HHI BWMS (HiBallast)</td>
<td>Republic of Korea</td>
<td>Basic</td>
<td>MEPC 60</td>
</tr>
<tr>
<td>KS BWMS (En-Ballast)</td>
<td>Republic of Korea</td>
<td>Basic</td>
<td>MEPC 60</td>
</tr>
<tr>
<td>TWECO BWMS (Purimar)</td>
<td>Republic of Korea</td>
<td>Basic</td>
<td>MEPC 61</td>
</tr>
<tr>
<td>AquaStar BWMS</td>
<td>Republic of Korea</td>
<td>Basic</td>
<td>MEPC 61</td>
</tr>
<tr>
<td>Kuraray BWMS</td>
<td>Japan</td>
<td>Basic</td>
<td>MEPC 61</td>
</tr>
</tbody>
</table>
Table 7: Ballast Water Management Systems with Type Approval Certification (G8)

<table>
<thead>
<tr>
<th>Approval Date</th>
<th>Name of Administration</th>
<th>Name of the Ballast Water Management System</th>
<th>Active Substances Employed</th>
</tr>
</thead>
</table>
| June 2008     | Norwegian Administration | PureBallast System                          | Free radicals Cl2-, ClB-,
| March 2011    | Norwegian Administration | PureBallast 2.0 & PureBallast 2.0 Ex        | Br2- and CO3-            |
| June 2008     | Federal Maritime & Hydrographic Agency, Germany | SEDNA® BWMS (Using Peraclean® Ocean System) (temporarily withdrawn from the market) | PERACLEAN® Ocean (Refer to MEPC 57/2/10, Annex 7) |
| September 2008 | Maritime Administration, Marshall Islands | Venturi Oxygen Stripping™ System (NEI) | None Used |
| January 2010  | Merchant Shipping Directorate, Malta | Electo-Cleen™ System | HOCI (OCl-), HOBr (OBr-), O3 (H2O2), OH- (Refer to MEPC 58/2/7, Annex 7) |
| April 2009    | Norwegian Administration | Hyde Guardian™ Ballast Water Management System | None Used |
| November 2009 | Ministry of Land, Transport and Maritime Affairs, Republic of Korea | NK-O3 BlueBallast System | O3 (Refer to MEPC 59/2/16, Annex 6) |
| November 2009 | Norwegian Administration | OptiMarin Ballast System | None Used |
| December 2009 | Ministry of Land, Transport and Maritime Affairs, Republic of Korea | GloEn-Patrol™ | MPUV Irradiation (Refer to MEPC 60/2/11, Annex 4) |
| March 2010    | Maritime Bureau, Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government | Hitachi ClearBallast™ | PAC, FeO3, and PASA (Refer to MEPC 59/2/19, Annex 4) |
| August 2010   | Maritime Safety Authority, South Africa | Unitor Ballast Water Treatment System | TG Environmentalguard (Main Ingredient - Na2SO3)
| December 2010 | Federal Maritime and Hydrographic Agency, German Administration (BSH) | ClearBallast (RWO) | NaOCl and O3 (Refer to MEPC 60/2/11, Annex 7) |
|               |                        |                                             | Hydroxyl Radicals and Free Active Chlorine (HOCI/OCl-)
|               |                        |                                             | (Refer to MEPC 59/2) |
Section 3

BWT Considerations

This section summarizes the practical realities of shipboard ballast water treatment systems to assist in the evaluation of treatment technology options and plan for their installation. Included are discussions of the key features of ships’ ballast water handling systems and practices, and the features of the various treatment technologies that will have an important impact on the ship or ballast practices and costs.

Considerations for Selection of Treatment Systems

Overview

Ballast water treatment remains an evolving technology with an ever-growing number of manufacturers developing systems to meet the anticipated regulatory requirements. Readers are urged to contact ABS or review the latest IMO information to determine the current status of treatment system approvals. This current situation means that there is limited in-service experience for the systems being offered and there is a general understanding that no single system is suitable for all ship types or service. The owner/operator must make a considered choice for the ballast water treatment that best suits the demands of the ship and service taking into account vendor specifications and the extent of shore side and shipboard testing carried out during the type approval process. A careful engineering analysis of the following factors bring order to the decision-making process. These issues are discussed in some detail as follows.

Ship and Vessel Service Characteristics

- Ship type and capacity
- Ballast water handling practices including NOBOBS (no ballast on board ships)
- Ballast water characteristics
- Vessel service characteristics
- Ballast system characteristics

Treatment Technology Factors

- Treatment method
- Treatment system pressure drops
- Equipment size and space requirements
- Materials, equipment protection (IP rating) and hazardous spaces
- Power requirements
- Impacts on ballast tank and pipe corrosion
- Health and safety (handling, operation and maintenance)

General Treatment System Considerations

- Proven efficacy and official approvals
- Vendor qualifications and reputation
- Maintenance requirements and system reliability
- Simple operation (control and monitoring)
- Life cycle costs
- Serviceability and availability of spare/replacement parts

Challenges for Installation Engineering

- Intake/discharge isolation (cross-contamination)
- Sampling and in-service testing
- Maintaining ballasting flexibility
Ship & Vessel Service Characteristics

Ship Type & Capacity

In most instances, the ship type will be the largest single determinant in selecting a suitable treatment system. For this purpose it is convenient to consider two groups of ship types: high ballast dependent ships such as tankers and bulkers; and low ballast dependent ships such as containerships, general cargo ships, and cruise ships. These groupings are based on differences in total ballast capacity, amount of discharge at any one port and ballast flow rates.

As the data in Table 8 indicates, there is a wide range of ballast capacities and pumping rates common to the commercial ship sector. Notably, the high ballast-dependent vessels regularly sail in ballast only conditions (without cargo). Their pump rates are designed to allow full load or discharge in a fixed period of time to facilitate rapid port turnaround times (typically 12, 18 or 24 hours for ballast operations). The low ballast dependent vessels generally have smaller ballast capacities and also may rarely undertake a ballast only voyage. Their pumps do not typically have to handle a full load of ballast on a regular basis. Movement of ballast is more limited and often is a shift (one tank to another to adjust trim or heel) rather than a simple full ballast load/dischage operation.

Ballast Water Handling Practices

The proper sizing of a treatment system depends on the amount of ballast that has to be treated at any given port, more so than the total ballast capacity or maximum flow rate. If, through active ballast management, discharge can be reduced or eliminated then treatment demands decrease. For example, most containerships rarely need to discharge a full ballast load at any one time.

It also should be noted that a large amount of the treatment system prototype testing is done on moderately sized systems (< 250 m³/hour) or is scaled up from other industries and not all systems scale up well to the sizes required for the high ballast capacity pumping rates or volumes of several thousand m³/hour.

Another ballast practice issue that impacts treatment selection is how accumulated mud and silt in the ballast tanks is addressed. This residue itself can contain invasive species even when the tank is empty of water (a NOBOB – no ballast on board condition). Even if ballast is loaded locally it can become contaminated by the residue in the tank. This may necessitate the treatment of ballast water on discharge as well as loading. If there is little mud accumulation and the tanks are cleaned regularly, this may be less of a concern and the treatment system can be selected accordingly. For those ships constructed in or after 2009, compliance with G12 guideline is to be applied.

Ballast Water Characteristics

Turbidity, salinity and silt content can impact the efficacy, maintenance or reliability of some technologies. If regular calls in a port are planned where the water has high mud/silt content or has a low salt content (fresh or brackish) these should be considered in the treatment technology selection.
Table 8: Ballast Water Capacity & Ballast Pump Rates by Vessel Type

<table>
<thead>
<tr>
<th>Vessel Category</th>
<th>Vessel Type</th>
<th>Representative Ballast Capacity (m³)</th>
<th>Representative Pump Rate (m³/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Ballast Dependent Vessels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk Carriers</td>
<td>Handy</td>
<td>18,000</td>
<td>1,300</td>
</tr>
<tr>
<td></td>
<td>Panamax</td>
<td>35,000</td>
<td>1,800</td>
</tr>
<tr>
<td></td>
<td>Capesize</td>
<td>65,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Tankers</td>
<td>Handy</td>
<td>6,500</td>
<td>1,100</td>
</tr>
<tr>
<td></td>
<td>Handymax-Aframax</td>
<td>31,000</td>
<td>2,500</td>
</tr>
<tr>
<td></td>
<td>Suezmax</td>
<td>54,000</td>
<td>3,125</td>
</tr>
<tr>
<td></td>
<td>VLCC</td>
<td>90,000</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td>ULCC</td>
<td>95,000</td>
<td>5,800</td>
</tr>
<tr>
<td><strong>Low Ballast Dependent Vessels</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Containerships</td>
<td>Feeder</td>
<td>3,000</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Feedermax</td>
<td>3,500</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Handy</td>
<td>8,000</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Subpanamax</td>
<td>14,000</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Panamax</td>
<td>17,000</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Postpanamax</td>
<td>20,000</td>
<td>750</td>
</tr>
<tr>
<td>Other Vessels</td>
<td>Chemical Carriers</td>
<td>11,000</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Passenger Ships</td>
<td>3,000</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>General Cargo</td>
<td>4,500</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Ro/Ro</td>
<td>8,000</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Combination Vessels</td>
<td>7,000</td>
<td>400</td>
</tr>
</tbody>
</table>

Note: Representative values are nominal values that reflect a combination of data sources and vessel sizes in each category.

**Vessel Service Characteristics**

The vessel service or trade route may also be critical for treatment system selection. For example, certain ship types may not be discharging ballast in the US so there will be no concern for US regulations other than the reporting and recordkeeping requirements. The key regulatory requirement and efficacy standards will be those from IMO. If treatment options for local requirements are too expensive, then operators that trade in those areas only occasionally may opt to forego shipboard installation of additional treatment capability. Instead they may adjust their ballast management to avoid discharge or pay high use costs for a shore/port based system (where available).

**Common Ballast System Characteristics**

There are also a number of other vessel features related to ship type that are not exclusive to the high/low ballast dependent categorization defined above yet have an impact on treatment system selection. These include the number of separate ballast systems (e.g., oil tankers often have two, one in way of the cargo area and one aft of the cargo), whether eductors are used to supplement ballast discharge, small or crowded engine rooms, or explosion proof ballast equipment requirements. How these features represent design challenges for treatment systems are discussed in the following sections.
Treatment Technology Factors

The second most important set of factors in selecting a suitable treatment system, after ship type and service, are the operating characteristics and requirements of the individual treatment technologies. As noted in Section 2 of this Advisory, BWT Technologies, there are several type approved technologies that have satisfied the IMO D-2 standard and numerous technologies being actively researched and implemented that should be able to meet the IMO discharge standards. These technologies differ in method and rate of application, scalability, required holding time, power and related system requirements, impacts on corrosion and inherent safety. Each ship’s design, as well as an owner’s particular operating practices and internal risk assessments, will determine how important each of these factors is in the selection process. Taken together, these factors and how the treatment systems address them, indicate the level of analysis required for effective implementation of the particular treatment system.

The following describes treatment factors that should be considered.

Treatment Method

The methods and technologies being considered for ballast water treatment can be grouped by basic approach as follows:

- Mechanical systems (filtration or separation)
- Physical disinfection (UV radiation, cavitation, de-oxygenation, etc.)
- Chemical treatment (biocides and electro-chlorination)

Each system has a few fundamental characteristics that impact its suitability for certain ship types, service or flow rates. Most of the treatment systems use a combination of two or more of these technologies to overcome an individual technology’s shortcomings.

Mechanical Systems

These require redirecting the full ballast flow through filters, hydrocyclones or other separators. For high volume applications, the size of the equipment required can be problematic. If they are used during ballast discharge, the filtrate must be maintained on board. High sediment loads can cause problems for filters.

Physical Disinfection

Ultraviolet radiation and cavitation require processing of the entire ballast flow but holding time is not required as treatment is complete once the water passes through the equipment. UV exposure is usually done at both intake and discharge. Its effectiveness degrades with cloudy or turbid water that restricts light penetration.
De-oxygenation can be done at intake to the full ballast flow or directly in the ballast tanks with bubblers. However, the full kill rates may take several days to achieve so the ballast tanks must also have a closed vent system and be fully inerted.

**Chemical Treatment**

These treatments are dosed into the existing ballast piping during intake or directly into the ballast tanks. The dosage rates must be adjusted to provide the desired kill rate. The chemicals are usually lethal within several hours of treatment so long holding times are not required. However, the chemicals must be neutralized or be allowed to become biologically ineffective before the ballast water can be considered safe for discharge.

**Treatment System Pressure Drops**

The treatment systems that process the full ballast flow through filters, separation systems or venturi's, create added resistance to ballast flow. The pressure drops for such elements vary, with most systems claiming from less than 1 bar to about 2 bar. In some cases, back pressure valves may need to be added to the system after a separator to provide sufficient backpressure for clearing out sludge and/or self-cleaning. If the installation requires significant lengths of new ballast piping and valving then some additional pressure drops will be introduced that could prove significant.

The self cleaning or back-flushing operation will redirect some of the ballast flow directly overboard and reduce the flow rate into the tank further. Some hydrocyclones redirect between 5 percent to 10 percent of the flow stream for sludge removal.

The pressure drops and self cleaning process will impact in-service flow rates and system design pressure. For most ships it is not expected that ballast pumps will need to be upgraded. However, the actual flow rates of ballast delivered to the tanks achievable with the selected system must be used when evaluating ballasting times and operation of the treatment system. It could be that ballasting

---

**Table 9: Important Treatment Method Characteristics**

<table>
<thead>
<tr>
<th>Treatment Process</th>
<th>Method of Treatment</th>
<th>When Applied</th>
<th>Time for Lethality</th>
<th>Corrosion Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine Generation</td>
<td>Use electrolytic cell to generate chlorine and bromine that act as biocides. Next, sodium sulfate neutralizes the ballast water prior to discharge. As long as free chlorine exists in the tank, biocide will be active so dosage can be adjusted to keep biocide always active.</td>
<td>At uptake and neutralize at discharge</td>
<td>Hours</td>
<td>High dosage levels promote steel corrosion</td>
</tr>
<tr>
<td>Chemical Application</td>
<td>Mix proprietary chemicals with the ballast water in metered dosage rates at intake to kill living organisms. Chemicals degrade over time so ballast will be safe to discharge.</td>
<td>At uptake via eductor 24 hours</td>
<td>High dosage levels promote steel corrosion</td>
<td></td>
</tr>
<tr>
<td>Filtration &amp; Radiation</td>
<td>Filtration of the incoming water, usually with self-cleaning 50 micron filters, in parallel with discharge of filtrate to the waters where intake takes place. Ballast water is exposed to a form of radiation, such as UV energy or other hydroxyl radical generator, to kill smaller organisms and bacteria.</td>
<td>At uptake for filter and UV and at discharge for UV</td>
<td>At treatment</td>
<td>No effect</td>
</tr>
<tr>
<td>De-oxygenation</td>
<td>Mix inert gas generated on board with the ballast water, either by a venturi eductor or by bubbling from pipes in the tanks. This removes oxygen from the water and lowers ph, therefore killing the living organisms. This process requires the atmosphere in the ballast tank be maintained in an inert condition.</td>
<td>At uptake for some systems and in tanks for others</td>
<td>4 to 6 days</td>
<td>Relatively less corrosive</td>
</tr>
<tr>
<td>Ozone Generation</td>
<td>Ozone is generated on board and acts as a biocide. It is applied during the ballast pumping process by eductor either at uptake or discharge. It can be combined with filtration or other methods of treatment.</td>
<td>At uptake for some systems and at discharge for others</td>
<td>Up to 15 hours</td>
<td>Limited effect as ozone has short life. If treated at discharge, no effect.</td>
</tr>
</tbody>
</table>
with some treatment systems with high pressure drops and self-cleaning systems could take 20 percent longer than ballasting without treatment.

It should also be noted that at some level of additional system resistance, gravity ballasting may no longer be feasible because the pressure differentials with the sea water are reduced and acceptable flow rates cannot be maintained. Some separation equipment simply cannot run without sufficient system pressure drop. This will ultimately increase the total power required for the ballasting operation because the main pumps will have to be operated for a longer period.

**Equipment Size & Space Requirements**

Treatment systems come in all shapes and sizes. The footprint requirements can vary from 1 to 25 m² for a system that can handle 200 m³/hour. For a 2,000 m³/hour system the space requirements can be 1 to 100 m². Systems that use filtration or require generating equipment for disinfection, inert gas generators for example, tend to increase in size with ballast flow rates more than other systems that treat with chemical dosing.

Another very important space consideration is the ballast piping itself. If the treatment system requires new branch lines to be installed, this can sometimes have an even greater impact on the space requirements than the treatment equipment itself. In most engine rooms, the ballast piping is the largest pipe used. On small containerships with medium capacity pumps it can be over 250 mm. In the high ballast capacity ships it can easily be over 500 mm diameter. It can be a challenge to find room for tie-in points to the manifold area around the ballast pumps as well as space in the engine room to run significant lengths of pipe to remote locations if sufficient room for a piece of treatment equipment is unavailable. Systems that do not require redirecting main ballast flow certainly have an advantage in this case.

In addition to the total or overall size of the treatment equipment, the system’s modularity may also impact the ease with which it can be installed in an existing engine room. Taking delivery of a system preassembled on a skid and expecting it to be installed in a single lift is unrealistic unless it is going in at new construction. To reduce installation costs and time, system components will usually be lifted and fitted separately. So the ability of a system to be easily broken down into modules of convenient size and located in various areas in the engine room gives the installer many more options for completing the work.

Not to be overlooked in the search for space for system installation is the need to provide for adequate access to the equipment for maintenance. This can include ladders and platforms, additional lighting, lifting eyes or crane rails, space for storage and handling of consumables and cleaning of internal components (as required). When necessary, space requirements for storage and handling of chemicals used in treatment systems should also be considered. This space can be outside the engine room and may require a specific firefighting system, enhanced ventilation system, etc. Requirements related to the Material Safety Data Sheet (MSDS) are described later in this Advisory.

**Materials, Equipment Protection (IP Rating) & Hazardous Spaces**

A ballast water treatment system must meet all the normal requirements for shipboard materials, equipment protection and hazardous space safety. The materials used in the system components and the level of equipment protection (IP rating) provided should be reviewed at the type approval stage and certified as to be in compliance with the class requirements for similar equipment installed in similar locations on board. One important aspect of this approval is a review of the materials for fire rating where the reviewing authority deems the treatment system an ‘essential’ system. In that case, some plastic pipe materials may not be allowed. Additionally, specific valve materials and remote operation/shut downs may be required. These issues are not normally a concern for shipowners, unless they wish to specify higher grade materials for longer design service life and lower maintenance costs.

Critical to selecting a system however, is an understanding of the rules and regulations pertaining to the equipment location, specifically the placement of electrical equipment in a hazardous space. Electrical equipment installed in an engine room does not have to meet the requirements to be considered intrinsically-safe (EX ia or EX ib rated). However, the installation of electrical equipment in a hazardous space (such as a cargo pump room on a tanker) would mandate that specific class and statutory requirements aimed a lowering risks associated with combining electrical equipment and a potentially explosive atmosphere be addressed.
These traditional class and statutory requirements limit the electrical equipment that can be installed in a cargo pump room to intrinsically-safe equipment including certified lighting fixtures, a fire extinguishing system alarm, general alarm and communication equipment and a through-run of cables in extra heavy pipe. The placement of ballast water treatment systems in a pump room, on board a tanker constructed in accordance with these rules and regulations, that requires electrical power such as UV lamp banks or a current of more than 20 milli-amps, would not appear to be in compliance.

The application of the international standard IEC 60092-502 entitled “Electrical Installations in Ships – Part 502: Tankers – Special Features” as referenced by SOLAS Regulation II-1/45.11 for ships constructed on or after 1 January 2007, is in general less restrictive on the certification of electrical equipment than traditional class Rules.

The installation of a ballast water treatment system in a pump room may be possible on tankers constructed on or after 1 January 2007 provided the tanker is operated and maintained in accordance with the IEC standard. Such an installation would be contingent on compliance with the requirements contained in IEC 60092-502; the submission of a detailed risk assessment addressing those aspects not covered in the IEC standard; and the approval of the designated approving authority.

Tanker owners and operators are also reminded that ballast water from tanks adjacent to cargo oil tanks cannot pass through or be treated by a ballast water system located in the engine room.

Power Requirements

Electrical power consumption by ballast water treatment systems is potentially a significant hurdle for some technologies on the high ballast dependent ships. Large power consumers such as UV light banks, electrolytic chlorination systems and de-oxygenation systems can require 150 to over 200 kW for a 2,000/m³ treatment flow rate. If these systems must operate when other large shipboard consumers are also operating, total ship service electrical generating capacity may be insufficient.

The large electrical loads are also the main operating cost for these systems. In contrast, treatment systems that rely on chemical biocides and preparations that can be dosed into the ballast flow have an almost insignificant electrical load impact but require storage space, handling and dispensing equipment.
Impacts on Ballast Tank & Pipe Corrosion

For all ships, but especially the high ballast dependent ships, the battle against steel wastage due to salt water-induced corrosion can be the single largest maintenance cost as the vessel ages. Treatment systems that change the chemical composition of the ballast water and/or the atmosphere in the ballast tanks can impact the corrosion rates in the tanks and piping. If not designed and handled properly, treatment systems may also damage ballast tank coatings resulting in increased coating maintenance and ultimately increased corrosion as well.

Systems that remove oxygen and maintain an inert, oxygen-deprived condition in the tanks can offer significant reductions in corrosion rates. Some of the change in oxidation rate is attributable to changes in pH caused by the treatment. Some vendor studies have actually concluded that savings on steel and coating renewals over the life of the vessel are much greater than the life cycle costs of the treatment systems. Alternatively, many of the chemical biocides and preparations, including ozone, have been linked to increased corrosion rates.

Experimental data is not always conclusive regarding the impact of chemical disinfectants in actual service conditions in ships' ballast tanks with standard tank coatings and anodes, normal cycling of ballast levels and chemical concentrations required for treatment. Even de-oxygenation systems can cause accelerated corrosion if they completely remove the oxygen and create a condition that promotes anaerobic-type, microbiologically-influenced corrosion. This could be in the form of acid-producing bacteria (APB) and sulfate-reducing bacteria (SRB). The condition may be accentuated if there is an alternating oxygenated/de-oxygenated condition. In order for de-oxygenation to be beneficial for corrosion protection, it has to reduce the oxygen levels sufficiently to slow oxidation and kill any biofilms that might form, but not so low as to provide an atmosphere conducive to the growth of APBs and SRBs.

With the current available data, it is difficult to predict how different treatment systems will change corrosion rates. At this point, it is necessary to move forward with an understanding of this uncertainty and plan maintenance and inspection intervals to suit expected risks appropriately. Coating manufacturers should also be consulted regarding the reaction of their coatings to the planned additives. Only when sufficient operational experience is gained with given treatment systems will clearer guidelines be possible.

Health & Safety (Handling, Operation & Maintenance)

The use of chemical biocides and other active substances on board ships raises a concern over the health and safety of those responsible for operating the equipment and handling the materials, as well as the risk of unintentional discharge into the environment. Treatment systems that use active substances or preparations must undergo
a strict review and approval process to identify persistence, bioaccumulation and toxicity. If the system is given final approval by IMO, this indicates that persistence, bio-accumulation and toxicity are below threshold levels and that, if the substances are handled as directed, they are considered acceptable for shipboard use.

Every system using active substances should be provided with a Material Safety Data Sheet (MSDS) which describes the proper storage and handling procedures as well as the information on the quantity to be added to the ballast water and the maximum allowable concentration of the substances in the treated water.

It is important to note that limits for the level of active biocides that may remain in the discharged ballast can also be regulated by local water quality regulations and can vary by port. If discharging in sensitive areas, a treatment system with difficult to control biocide inactivation might not be the right choice. At the very least, the manufacturer should be requested to provide written confirmation that the effluent meets the requirements within the local jurisdictions that the vessel is likely to operate in.

Compliance with the applicable IMO guidelines should indicate that all reasonable precautions have been taken to protect the health and safety of the crew and environment. Nevertheless, it does put an added hazardous material management burden on the crew. The skill and training of the crew and their ability to manage this safety risk should be considered when selecting a treatment system.

**General Treatment System Considerations**

All ballast water treatment technologies share certain common selection criteria that should be considered in addition to the ship and technology specific factors.

**Proven Efficacy & Official Approvals**

First and foremost, a system must meet the discharge standard applicable to the vessel’s voyage where ballast discharges are planned or likely. General worldwide service is covered by the IMO Convention’s requirements but some local authorities, such as the state of California, have more stringent requirements and earlier implementation dates. A certificate of type approval from a flag Administration would indicate that, under test conditions, the system meets the discharge standards required. Unless the installation is part of a prototype or type approval test, the equipment supplier should be able to produce the type approval certificate. Systems with type approval are also listed on the IMO website. This formal approval of the
equipment will be necessary if the vessel is to obtain the IMO Ballast Water Management Certificate showing compliance with the BWM Convention following successful system functional tests on board.

**Vendor Qualifications & Reputation**

As with any piece of equipment, the ability of the vendor or manufacturer to deliver the product on time and in the quantities requested is very important. However with this emerging technology, the production capacity is unproven and still very small in most cases. Some manufacturers may suffer from long lead times on orders, especially if demand increases rapidly. Even though production facilities are subject to quality control review by the type approval authority, until a track record is established, manufacturing quality and reliability can be an unknown. Those systems relying on existing technologies or marine components will have an advantage in this regard.

**Maintenance Requirements & System Reliability**

There is insufficient experience with treatment system options to establish a good baseline for system reliability. Those systems relying on existing technologies or marine components will be able to provide better reliability estimates. Lacking in-service experience, an indication of reliability risk may be available by considering the system complexity. Filters, UV light chambers and simple chemical dosing systems are among the least complex options and regular maintenance is possible with ship’s crew. Electrochlorination and other chemical generating systems as well as systems with more than two stages of treatment can be considered among the most complex.

**Simple Operation: Control & Monitoring**

All treatment systems should provide a simple to use remote control panel at or near the main ballast control panel. It should include indicator lights for key valves and system operations and an on/off control. Most systems will provide main control panels near the equipment that allow local operation but also monitor system operation. Beyond this, it is up to the owner how far integration of the treatment system is carried in the main control/alarm/monitoring system. If full integration is required, additional tie-ins with system electronics may need to be special ordered from the manufacturer.

**Life Cycle Costs**

The bottom line concern for owners is the true life cycle cost of the system. Acquisition costs are the most straightforward to determine because they are directly quoted by the vendors and include all their sunk costs for research and development, approvals and certification. Installation costs vary from system to system and are more difficult to quantify. Installation costs include changes to existing piping, equipment and structure, as well as the direct equipment installation, connection, startup, testing and survey by the approval authority. Most systems will require some out of service time for the ship in order to complete the installation but none of those currently on the market is likely to require drydocking.

Establishing both installation and operating costs is difficult as both will vary significantly depending upon the type and size of ship, the system selected and prevailing market conditions. When evaluating the probable operating costs of a system, the following should be taken into account:

- Energy required to operate the system including electric power and fuel for generating treatment materials (ozone, inert gas and other biocides)
- Consumables such as chemicals, lamps and filter elements
- Crew labor to operate and maintain the system, including training

**Serviceability & Availability of Spare/Replacement Parts**

As noted in the Annex to Resolution MEPC.174(58), “Guidelines for approval of ballast water management systems (G8),” all working parts of the ballast water management system that are susceptible to wear or damage should be easily accessible for maintenance. Accordingly, owners and operators are to install the system in such a manner so the ship’s crew can perform routine maintenance which may include the replacement of filters, UV lights or other consumables in an efficient manner. In addition, owners and operators are encouraged to confirm the availability of spare or replacement parts and repair technicians on a worldwide basis.
Challenges for Installation Engineering

Many of the challenges related to engineering the actual installation of a ballast water treatment system are addressed in the section describing the treatment technology factors. These challenges can be especially acute when installing a system on an existing vessel. Finding solutions to treatment system back pressure and potential flow rate reductions, power consumption demands, control system integration and space requirements, as well as access for installation, can be difficult and costly.

As these are worked out with the vendor, design engineer and class the following additional factors should also be taken into consideration.

Intake/Discharge Isolation: Cross-Contamination

When designing the piping system modification required for treatment system installation, care is required to prevent any accidental cross-contamination of intake and discharge water. This is a concern for systems that redirect the main ballast flow. Cross-contamination can occur if contaminated water, either from the sea chest or a tank which may require treatment prior to discharge, passes through a pipe that is shared by the treated ballast water being discharged. Valves which do not provide a reliable seal may also allow some contamination of treated ballast.

The ideal isolation of intake and discharge flows is not always possible. However, in two pump ballast systems where flexibility in the ballasting/deballasting time is acceptable, it is recommended that one pump be dedicated for ballast intake and one for discharge. Transfers between tanks should be done by the ‘discharge’ or ‘clean’ pump unless treatment is active in the ballast tanks (as with de-oxygenation).

Sampling & In-Service Testing

Port State Control and other authorized regulatory officers may, at any time for the purpose of determining whether the ship is in compliance with the discharge requirements, come on board and take samples of the ballast water. Designing proper and convenient sampling and testing facilities should be considered an important part of the installation engineering. As noted in Section 1 of this Advisory, IMO G2, Guidelines for Ballast Water Sampling, calls for the sampling to be a simple and speedy process, applicable at the point of ballast discharge and safe to the ship and crew. The G2 guideline further contains very specific requirements for size, location and maintenance of isokinetic sampling ports.

Unfortunately, sampling and analysis methodologies to test for compliance with the Convention remain in development. While research is ongoing, there currently exists no specific guidance for the best way to take, handle and analyze samples. There are no protocols for the volume of water required, the conditions in which the samples are stored.
(e.g., light, temperature, storage container), how biota collection from a sample is accomplished, the statistical method used to count biota, nor direction on sample disposal (e.g. can it simply be discharged?).

The sample volume and method for biota collection are key to the design of the sampling facilities. They should include flexible hoses, holding tanks and work area. Unfortunately, with the sampling port required to be near the discharge that is often located in the engine room where space is limited, handling of significant quantities of water may be difficult to arrange or simply impractical.

**Maintaining Ballasting Flexibility**

Ideally, full ballast system operational flexibility can be maintained with the selected treatment system. However, providing for the treatment of all isolated ballast systems on board, maintaining maximum flow rates at all times and providing for stripping systems (eductors) to continue to be used, may not be necessary for particular ships or even cost effective. For example, a vessel that does not move significant ballast during normal operations may not need the treatment system to handle full pumping flow rates. Eductor-based stripping systems may not need special attention if the full treatment course is completed in the tank before discharge, or if the eductor power water can be taken from a treated source. Dedicating ballast pumps for intake and discharge may reduce flexibility but may simplify piping connections and lower the risk of cross-contamination.

**Obtaining As-built Vessel Information**

For most existing vessels, detailed as-built drawings of the ship’s ballast piping system and engine room arrangement may not be readily available. Nevertheless, detailed dimensional information is required for all vessel systems and outfits that may be impacted by the new equipment in order to properly evaluate locations for equipment installation and piping runs and avoid interferences. Further, installation sequence planning requires a detailed understanding of routes for equipment access and the minimum clearances available. Availability of suitable equipment lifting points also needs to be documented. Gathering of this information is important to a smooth installation (as well as possible treatment selection decisions) and should not be overlooked. Advanced techniques using 3-D laser scanning technology may be useful in this regard.

**Making a Treatment System Selection**

With such a wide array of ballast water treatment technologies available and the numerous, often competing constraints on any one system, the evaluation and selection of the best equipment is not straightforward. There are many factors to consider. This Advisory provides an overview of the principal considerations that an owner/operator should bear in mind when specifying a ballast water treatment solution.

As a first step in the evaluation process, the information contained in Table 10 should be considered. It summarizes the suitability of the primary treatment technologies with a range of vessel types and sizes.
As can be seen, in only a few cases are treatment technologies deemed unsuitable for particular vessel types. The selection process then must take up the details. As an aid for use in this process, a checklist of key questions and considerations has been included in the System Evaluation Checklist Section that follows. This can be useful in establishing criteria. The value and rating of each factor is left up to the individual responsible for making the decision on the systems to employ.

Table 10: Suitability of a Ballast Treatment System Type to a Vessel Type

<table>
<thead>
<tr>
<th>Vessel Category</th>
<th>Vessel Size Range</th>
<th>Chlorine Generate</th>
<th>Chemical Apply</th>
<th>Filter &amp; Radiate</th>
<th>De-oxygenate</th>
<th>Ozone Generate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bulk Carriers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handy-Handymax</td>
<td>&lt; 60,000 DWT</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Panamax-Kamsarmax</td>
<td>&lt; 60,000-90,000 DWT</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Capesize</td>
<td>&gt; 90,000 DWT</td>
<td>Except Large</td>
<td>Yes</td>
<td>Except Large</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Tankers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handy</td>
<td>&lt; 35,000 DWT</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
</tr>
<tr>
<td>Handymax-Aframax</td>
<td>35,000-120,000 DWT</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
</tr>
<tr>
<td>Suezmax</td>
<td>120,000-180,000 DWT</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
<td>Some Systems</td>
<td>Some Systems</td>
</tr>
<tr>
<td>VLCC</td>
<td>200,000-320,000 DWT</td>
<td>No, Too Large</td>
<td>Yes</td>
<td>No, Too Large</td>
<td>Some Systems</td>
<td>Some Systems</td>
</tr>
<tr>
<td>ULCC</td>
<td>&gt; 320,000 DWT</td>
<td>No, Too Large</td>
<td>Yes</td>
<td>No, Too Large</td>
<td>Some Systems</td>
<td>Some Systems</td>
</tr>
<tr>
<td><strong>Containerships</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder</td>
<td>&lt; 500-3,000 TEU</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Panamax</td>
<td>3,000-4,500 TEU</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Postpanamax</td>
<td>4,500-9,000 TEU</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ultralarge</td>
<td>&gt; 9,000 TEU</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Other Vessels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger Ship</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Gas Carrier</td>
<td>All Sizes</td>
<td>Except Large</td>
<td>Yes</td>
<td>Except Large</td>
<td>Some Systems</td>
<td>Some Systems</td>
</tr>
<tr>
<td>Chemical Carrier</td>
<td>All Sizes</td>
<td>Some Systems</td>
<td>Yes</td>
<td>Some Systems</td>
<td>Some Systems</td>
<td>Some Systems</td>
</tr>
<tr>
<td>Ro/Ro</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Combination Vessel</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>General Cargo</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fishing Vessels</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>OSVs</td>
<td>All Sizes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: For tankers, chemical carriers and gas carriers, some systems are not suitable, either because they are not designed to be installed in a hazardous atmosphere such as a tanker pump room or because they are not produced at the high capacity required for large tankers.
1. Ballast system arrangement
   a. Total ballast capacity
   b. Number of ballast tanks
   c. Minimum/maximum ballast tank size
   d. Are ballast tanks contiguous with cargo oil or other hazardous cargo tanks?
   e. Dedicated set of heel control tanks (FW or SW)?
   f. Number of separate ballast systems (not served by same pump)
   g. Proper and convenient sampling and testing facilities

2. Ballast system equipment
   a. Number of ballast pumps and rating (flow rate and pressure for each)
   b. Overall ballast rate (m$^3$/hour)
   c. Ballast pump location (engine room, pump room, main deck, etc.)
   d. Main ballast line configuration (ring main or single line)
   e. Type of stripping system, if any
   f. Are all ballast system valves remotely operated?
   g. Are ballast pumps/piping shared with other systems (bilge, fire, cooling water)?
   h. Number and location of sea chests (height above bottom)
   i. Diameter of main ballast line to/from pumps
   j. Number and size of spare circuit breakers on main switchboard
   k. Estimated spare electrical capacity during ballasting operations
Ship & Service Characteristics that Impact BWT Selection
Owner Supplied Data

1. Ship type and capacity
   a. Ship type: high ballast dependent or low ballast dependent

2. Ballast water handling practices
   a. On average, how much ballast is loaded or discharged at any given port?
   b. What are the time constraints on ballast intake (how fast must it happen)?
   c. Maximum required flow rate for intake of ballast
   d. What are the time constraints on ballast discharge (how fast must it happen)?
   e. Maximum required flow rate for discharge of ballast
   f. Sediment build up in tanks (little, moderate, significant)
   g. Is treatment required for possible NOBOB condition?
   h. Minimum time ballast is held in a tank between port calls

3. Ballast water characteristics
   a. Are there freshwater ports encountered where ballast is taken in?
   b. Minimum salinity of brackish water encountered
   c. Turbidity or silt content of port water (low, moderate, heavy)

4. Vessel service characteristics
   a. Any unique service constraints or trading patterns regarding ballast use?
   b. Is there trade to special BWT zones: California, Great Lakes, Australia, etc.?
   c. Does active ballast management allow zero ballast discharge in some/all ports?

5. Ballast system characteristics
   a. What are the gravity intake/discharge practices?
   b. Can internal ballast transfer for trim, heel, bending moment control be easily accomplished?
1. **Treatment method**
   a. Description of technology offered (all stages)
   b. For UV system: lamp type, required minimum intensity and water clarity
   c. For chemical: Required minimum dosage rate and minimum holding time
   Neutralizing agents – how created, stored, dosed?
   How long before safe to discharge?
   Chemicals generated on board or supplied as preparations?
   d. For de-oxygenation: How much inert gas required?
   Minimum holding time
   Type of gas, fuel type and consumption to generate gas

2. **Treatment system capacity**
   a. Overall treatment capacity (m³)
   b. Overall treatment rate (m³/hour)

3. **Treatment system pressure drops**
   a. Expected pressure drops added by treatment system to main ballast flow
   b. Quantity of ballast redirected for cleaning or sludge discharge
   c. Is gravity intake/discharge possible with this system?

4. **Equipment size and space requirements**
   a. Total space required for treatment equipment
   b. Size of largest single component
   c. Weight of largest single component
   d. Space required for maintenance (element removal, etc.)

5. **Materials, equipment protection (IP rating) and hazardous spaces**
   a. IP rating of components
   b. EX rating of components
   c. Any special risk assessments performed to date for hazardous space installations?

6. **Power requirements**
   a. Average and maximum power requirements and operating voltage
   b. Duration of maximum power consumption as function of ballast process

7. **Impacts on ballast tank and pipe corrosion**
   a. Is there published R&D available regarding the impact on tank and pipe corrosion rates?

8. **Health and safety (handling, operation, maintenance)**
   a. Quantity of treatment chemicals needed (per ton of ballast water treated)
   b. For active substances: a copy of the MEPC final approval with recommendations
   c. For active substances: Material Safety Data Sheets
General Treatment System Considerations
Vendor Supplied Data

1. Proven efficacy and official approvals
   a. Copy of Type Approval Certificate issued by, on behalf of, a Government
   b. System limitations or operating guidelines from Type Approval process

2. Vendor qualifications and reputation
   a. Annual production capacity of manufacturer
   b. Which components are custom made or incorporate new/novel technology?
   c. How many units have been built at the factory to be used for this installation?
   d. Client referrals for previously installed systems

3. Maintenance requirements and system reliability
   a. How many units of similar capacity have been installed?
   b. What is average duration of operating experience per unit?
   c. What is standard maintenance protocol?
   d. What is expected service life?

4. Simple operation: control and monitoring
   a. Type of remote control system included
   b. Ease of connection to primary control and monitoring system

5. Life cycle costs
   a. Estimated power consumption for normal ballast operations
   b. Fuel consumption expected for inert gas generation
   c. Cost of consumables (chemicals, lamps, filter elements)
   d. Expected frequency of resupply of consumables for planned system size
   e. What major components are most likely to need replacement within 10, 15, 20, 25 years? What is their cost?
Challenges for Installation Engineering
Owner Supplied Data

1. Intake/discharge isolation: cross-contamination
   a. Can piping installation options provide good contamination protection?
   b. Can intake and discharge pumps be isolated and dedicated to that service?

2. Sampling and in-service testing
   a. Is there adequate space and facilities for sampling and testing?

3. Maintaining ballasting flexibility
   a. Can the treatment system options selected provide full ballast flexibility?

4. Other
   a. Is there space for all system components and ballast connections?
   b. What are the access openings and routes for bringing in new treatment system components?
   c. What are the access needs during system operation and maintenance?
   d. Are switchboard modifications required?
   e. Are control system modifications required?
Technical Information for Ballast Water Treatment Systems

The following pages summarize the key technical and performance data for treatment systems, which are currently being offered on the market that are in various stages of approval as of the publication of this Advisory. It should be noted that some ballast water treatment systems which use chemical biocides or de-oxygenation may require additional treatment prior to the water being discharged into receiving waters.

Systems with Type Approval Certification
1. PureBallast System, PureBallast 2.0 and PureBallast 2.0 Ex
2. Electro-Cleen™ System (ECS)
3. OceanSaver® Ballast Water Management System
4. Venturi Oxygen Stripping™ (VOS) System
5. Hyde Guardian™ Ballast Water Management System
6. NK-O3 Blue Ballast/Nutech O3
7. Optimarin Ballast System (OBS)
8. Hitachi ClearBallast™ System
9. GloEn-Patrol™ System
10. Union Ballast Water Treatment System
11. JFE BallastAce System
12. RWO CleanBallast System

Systems with Final Approval for Active Substances
1. Hamworthy Sedinox™ System
2. HHI EcoBallast System
3. FineBallast™ OZ System
4. Ecochlor® Ballast Water Treatment System
5. ARA Ballast System
6. BalClor™ System
7. OceanGuard™ Ballast Water Management System
8. BalPure® System
PureBallast System, PureBallast 2.0 & PureBallast 2.0 Ex

Methods: Filtration + ultraviolet/TiO2 (AOT)

Operational Notes: The system is based on advanced oxidation technology, or AOT. Titanium dioxide catalysts generate free radicals when hit by light. The radicals, whose lifetime is only a few milliseconds, break down the cell membrane of micro-organisms without the use of chemicals or the creation of harmful residues (the system was, nevertheless, approved under the G9 regime for Active Substances). During ballasting, water is processed through the filter to remove any particles or organisms larger than 50 microns in size. It then passes through the AOT treatment to the ship's ballast system. Back-flushing water is returned over board at the ballasting site. During deballasting, the filter is bypassed and the ballast water receives a second dose of AOT before being discharged overboard.

The system has been further developed: the number of UV lamps were reduced and a more efficient 40 micron mesh filter and a flow regulating valve were introduced. Both the PureBallast 2.0 and PureBallast 2.0 Ex systems have received type approval.

Manufacturer: Alfa Laval, Norway

Link/Reference: www.pureballast.alfalaval.com

Approval Status: Final Approval for Active Substances, July 2007
Type Approval, June 2008, Norway (PureBallast System)
Type Approval, March 2011, Norway (PureBallast 2.0 and PureBallast 2.0 Ex)
Electro-Cleen™ System (ECS)

Methods: Electrolysis/electrochlorination

Operational Notes: Disinfection is carried out directly by the electrical potential and by the generation of free chlorine, sodium hypochlorite, hydroxyl radicals and electrochemical oxidation through the creation of ozone and hydrogen peroxide.

Manufacturer: Techcross Company Ltd., Republic of Korea

Link/Reference: www.techcross.net

Approval Status: Final Approval for Active Substances, October 2008
Type Approval, December 2008, Republic of Korea
OceanSaver® Ballast Water Management System

Methods: Filtration + hydrodynamic cavitation + de-oxygenation (nitrogen) + electrodialytic process

Operational Notes: After filtration intense pressure pulses are used to create hydrodynamic cavitation of sufficient intensity to rupture cell membranes and destroy particles and organisms. The ballast water is then super saturated by the injection of nitrogen causing the oxygen dissolved in the water to be released, leaving the water in the tanks deficient of oxygen. The released oxygen and nitrogen is evacuated from the tanks via a controlled ventilation arrangement usually through a pressure-vacuum device so as to avoid the further natural release of nitrogen over time and to prevent potential contamination by outside air. The final stage of treatment incorporates an isolated electrodialytic process which is based on the principles of an electrochemical activation technology. This is applied to a small portion of flow (greater than 5 percent by volume) producing a disinfectant which is returned to the main flow after the cavitation and the nitrogen saturation. This greatly enhances the disinfectant properties. The activated substances naturally degrade over a very short period of time.

Manufacturer: OceanSaver AS, Norway

Link/Reference: www.oceansaver.com

Approval Status: Final Approval for Active Substances, October 2008
Type Approval, April 2009, Norway
Venturi Oxygen Stripping™ (VOS) System

Methods: De-oxygenation + cavitation + lowering pH

Operational Notes: Inert gas is introduced into the ballast during intake through a venturi system. The cavitation caused in the venturi system damages the organism and is the first stage physical treatment. The inert gas removes oxygen from the water and lowers the pH level. The ballast tanks are kept inerted to maintain the hypoxic condition. This condition kills living organisms during the holding period in the tank (one to 48 hours). There are no active substances used.

Manufacturer: NEI Treatment Systems LLC, United States of America

Link/Reference: www.nei-marine.com

Approval Status: Type Approval, September 2008, Marshall Islands
Hyde Guardian™ Ballast Water Treatment System

Methods: Filtration + ultraviolet light

Operational Notes: During ballasting, water is processed through the filter to remove any particles or organisms larger than 50 microns in size. It then passes through the UV treatment and to the ship's ballast system. Back-flushing water is returned over board at the ballasting site. During deballasting, the filter is bypassed and the ballast water receives a second dose of ultraviolet light before being discharged overboard. There are no active substances used.

Manufacturer: Hyde Marine, Inc., United States of America

Link/Reference: www.hydemarine.com

Approval Status: Type Approval, April 2009, United Kingdom
NK-O3 Blue Ballast System/Nutech O3

Methods: Ozone + thiosulphate neutralizer

Operational Notes: The conversion of oxygen into ozone is carried out by an electric discharge field. Ozone is then injected into the ballast stream at the outlet of the ballast pumps and kills a percentage of invasive marine species by direct contact. The remainder of the invasive marine species are killed when the ozone reacts with bromine that naturally occurs in sea water to create other biocides. The ozone and bromine related biocides naturally decay. Only trace amounts of the bromine compounds remain in the treated water. If the levels are too high, a neutralizer injects thiosulphate to reduce them to acceptable levels. The ozone system produces a low concentration of active substances.

Manufacturer: NK Company, Ltd., Republic of Korea
Nutech O3, Inc., Republic of Korea

Link/Reference: www.nkcf.com
www.nutech-O3.com

Approval Status: Type Approval, October 2009, Republic of Korea
Final Approval for Active Substances, November 2009
Optimarin Ballast System (OBS)

Methods: Filtration + ultraviolet light

Operational Notes: During ballasting, water is processed through the filter to remove any particles or organisms larger than 40 microns in size. It then passes through the UV treatment and to the ship's ballast system. Back-flushing water is returned over board at the ballasting site. During deballasting, the filter is bypassed and the ballast water receives a second dose of ultraviolet light before being discharged overboard. There are no active substances used.

Manufacturer: Optimarin AS, Norway

Link/Reference: www.optimarin.com

Approval Status: Type Approval, November 2009, Norway
**Hitachi ClearBallast™ System**

**Methods:** Flocculent injection + magnetic separation + filtration

**Operational Notes:** Coagulation technology forms magnetic flocs by adding and agitating a coagulant and magnetic powder to the sea water to capture plankton, viruses, mud and sand. A high speed magnetic separator collects the magnetic flocs and the residual flocs are removed with a filter separator. Onboard storage of premixed flocculants/chemicals required. Accumulation, storage and disposal of sludge is required.

**Manufacturer:** Hitachi Plant Technologies, Ltd. and Mitsubishi Heavy Industries, Ltd., Japan

**Link/Reference:** www.hitachi-pt.com

**Approval Status:** Final Approval for Active Substances, July 2009
Type Approval, March 2010, Japan
GloEn-Patrol™ System

Methods: Filtration + ultraviolet radiation

Operational Notes: During ballasting, water is processed through the filter to remove any particles or organisms larger than 50 microns in size. The ballast then passes through the UV treatment unit utilizing high intensity, medium pressure UV lamps for sterilization and on to the ship’s ballast system. Back-flushing water is returned overboard at the ballasting site. During deballasting, the filter is bypassed and the ballast water receives a second dose of UV before being discharged overboard.

Manufacturer: PANASIA Co., Ltd., Republic of Korea

Link/Reference: www.worldpanasia.com

Approval Status: Type Approval, December 2009, Republic of Korea
                Final Approval for Active Substances, March 2010
                Type Approval for Explosion Proof System, June 2010, Norway
Unitor Ballast Water Treatment System  
(Technology provided by Resource Ballast Technology)

**Methods:**
Mechanical cavitation + ozone + sodium hypochlorite injection + filtration

**Operational Notes:**
The ballast water is treated on intake only. Cavitation and the application of the disinfectants electro-chlorination with sodium hypochlorite and ozone oxidation all take place. A screen-type self-cleaning filter is installed after the pump for the physical separation. The cavitation creates very strong sheer forces that effectively rupture the aquatic organisms. Electrodes mounted inside the reactor vessels produce sodium hypochlorite at a concentration of less than 1.5 ppm. A small ozone generator incorporated in the control system provides ozone at less than 1.5 ppm. The ozone provides disinfection both in brackish and fresh water. Both these disinfectants degrade rapidly without any effect on discharged ballast. The disinfectants employed are produced within the system and thus no additional facilities for the storage, make-up or dosing of chemicals are required.

**Manufacturer:** Resource Ballast Technologies (Pty.) Ltd., South Africa

**Link/Reference:** www.wilhelmsen.com

**Approval Status:** Final Approval for Active Substances, March 2010  
Type Approval, August 2010, South Africa
**JFE BallastAce System**  
*(using TG Ballastcleaner & TG Environmentalguard)*

**Methods:** Filtration + chlorination + cavitation + residual control

**Operational Notes:** During ballasting, mechanical separation removes organisms larger than 35 microns. Back-flushing water is returned over board at the ballasting site. Chemical dosing with sodium chloride and sodium sulfite precedes a mechanical treatment with cavitation in multiple venturi tubes. A residual oxidizing agent is quenched by a reducing agent at discharge.

**Manufacturer:** JFE Engineering Corporation, Japan  
(in cooperation with the Toagosei Group, Japan)

**Link/Reference:** www.jfe-eng.co.jp

**Approval Status:** Final Approval for Active Substances, March 2010  
Type Approval, May 2010, Japan
**RWO CleanBallast System**

**Methods:** Filtration + electro-chemical oxidation

**Operational Notes:** A disk-type filter system is used for mechanical separation to 40 to 45 microns when taking in ballast water followed by the EctoSys® disinfection unit. This unit is an electro-chemical system utilizing electrodes with high oxygen over potential that produces powerful disinfectants such as hydroxyl radicals and also provides direct oxidation of microorganisms on the electrode surface. No chemicals or precursor substances are added to the ballast water. Neither the hydroxyl radicals nor any of the theoretically produced by-products are bio-accumulative or persistent. Ballast water can also be run through the disinfection unit at discharge.

**Manufacturer:** RWO GmbH, Marine Water Technology, Germany

**Link/Reference:** www.rwo.de

**Approval Status:** Final Approval for Active Substances, July 2009
Type Approval, December 2010, Germany
Hamworthy Sedinox™ System

Methods: Filtration + electrolysis (chloride ion disinfectant)

Operational Notes: This is a two-stage treatment. The first, the Sedimentor, is a hydrocyclone that removes sediment and biota during uptake. The second stage, the Termanox, is an electrolytic process based on the electrolysis of sodium chloride present in seawater. The Sedinox unit is the control system.

Manufacturer: Hamworthy, PLC, the Netherlands
(formerly Greenship BV, the Netherlands)

Link/Reference: www.hamworthy.com

Approval Status: Final Approval for Active Substances, July 2009
**APPENDIX**

**HHI EcoBallast System**

**Methods:** Filtration + ultraviolet light

**Operational Notes:** During ballasting, water is processed through the filter to remove any particles or organisms larger than 50 microns in size. The ballast then passes through the UV treatment unit utilizing high intensity, medium pressure UV lamps for sterilization and on to the ship’s ballast system. The UV lamps are arranged in a unique helix arrangement to maximize probability of exposure. Back-flushing water is returned overboard at the ballasting site. During deballasting, the filter is bypassed and the ballast water receives a second dose of ultraviolet light before being discharged overboard.

**Manufacturer:** Hyundai Heavy Industries, Republic of Korea

**Link/Reference:** [www.hhi.co.kr](http://www.hhi.co.kr)

**Approval Status:** Final Approval for Active Substances, March 2010
FineBallast™ OZ System

Methods:  Cavitation (by high shear) + ozonation

Operational Notes:  The system uses an inline pre-treatment to preventing blockage of the disinfecting unit followed by a mechanical treatment via a special pipe and then adding ozone to the water. The ozone-treated water is stored in the ballast tank for at least 48 hours to allow for the oxidizing and disinfecting properties of bromate (generated from the reaction of ozone and seawater) to become ineffective. The half-life period of the bromate ion is, on average, 12 hours. The unit then decomposes the oxidants remaining in the ballast water at the time of discharge. The ozone generator contains multiple electrodes which convert a part of oxygen in the gas to ozone. The power supply unit converts the power type from commercial frequency and low voltage to medium frequency and high voltage which is most suitable for ozone generation. A gas/liquid separation unit is employed to prevent ozone that does not react from flowing into the ballast tank.

Manufacturer:  Mitsui Engineering & Shipbuilding Co., Ltd., Japan

Link/Reference:  www.mes.co.jp

Approval Status:  Final Approval for Active Substances, October 2010
Ecochlor® Ballast Water Treatment System

Methods: Filtration and chlorine dioxide (ClO2) treatment

Operational Notes: The system uses a two-step treatment process. The first step is filtration with a 40 micron stainless steel mesh filter. The second step is the generation and injection of chlorine dioxide into the incoming ballast water stream. The filters are placed in close proximity to the ballast water pumps, but the treatment system can be installed in any convenient location on board the vessel.

The filter unit uses a filter-cleaning technology that does not require typical back-flush cycles. This allows for continuous filtration without significantly reducing the amount of water that can be filtered during ballast water uptake.

Manufacturer: Ecochlor, Inc., United States of America

Link/Reference: www.ecochlor.com

Approval Status: Final Approval for Active Substances, September 2010
ARA Ballast System
(Basic Approval as Blue Ocean Guardian BWMS)

Methods: Filtration + ultraviolet light + plasma

Operational Notes: The system operates during ballasting and de-ballasting. The filtration module serves to reduce the inflow of organisms in the ballast tank to a minimum. This filtration module does not allow for the piling of sediments. The ballast then passes through the medium pressure ultraviolet light (MPUV) module and then the plasma module. The water is re-treated by MPUV during de-ballasting to avoid possible regrowth of aquatic organisms in the ballast water tank.

Manufacturer: Samkun Co., Ltd., Republic of Korea

Link/Reference: www.sankunok.com

Approval Status: Final Approval for Active Substances, October 2010
BalClor™ System

**Methods:** Filtration + electrolysis (sodium hypochlorite)

**Operational Notes:** In the first stage, ballast water is filtered by an automatic backwashing filter with a 50 µm screen to remove warm organisms that are larger than 50 microns. During the disinfection stage a small side stream of the filtered ballast water is delivered to the electrolytic unit to generate the oxidants of high concentration (mainly sodium hypochlorite solution), then the oxidants are injected back into the main ballast stream to provide disinfection. If the residual TRO level in the treated ballast water exceeds 0.1 ppm a sodium thiosulfate solution is added to the discharge pipe to neutralize residual oxidants.

**Manufacturer:** Qingdao Sunrui Corrosion and Fouling Control Co., People's Republic of China

**Link/Reference:** www.sunrui.com.cn

**Approval Status:** Final Approval for Active Substances, October 2010
OceanGuard™ Ballast Water Management System

Methods: Filtration + electrocatalysis + ultrasonic treatment

Operational Notes: The mechanical filter (full automatic backflushing) has a filter mesh of 50 microns that is used to remove particles and viable organisms greater than or equal to 50 microns in minimum diameter. The biological efficacy is achieved mainly through active substances generated in water. The ultrasonic treatment acts as a supplementary treatment to the electrocatalysis. To make sure that the ballast water being discharged can satisfy the requirements of Regulation D-2, a second ultrasonic treatment is required.

Manufacturer: Qingdao Headway Technology Co., Ltd., Norway

Link/Reference: www.headwaytech.com

Approval Status: Final Approval for Active Substances, October 2010
BALPURE® System

Methods: Filtration + electrolysis (hypochlorite and hypobromite derivatives)

Operational Notes: A small side stream of ballast water is delivered to the electrolytic unit (electrolyzer) after passing through a flow orifice and flow transmitter that provides confirmation of proper flow. The seawater which passes through the electrolytic unit generates oxidants (hypochlorite and hypobromite derivatives). The solution of depleted seawater, oxidants and hydrogen gas then passes through a patented cyclone to separate the hydrogen. The hydrogen is diluted with air using a blower to a safe level. The oxidants are injected back into the main ballast stream on the discharge side of the ballast pump(s) to match the seawater-oxidant demand. The biocides react in the pipe with both inorganic and organic species in the ballast water to provide effective disinfection as the harmful organisms and non-indigenous species which are inactivated and/or destroyed the oxidant concentration in the ballast water is reduced to 1 ppm. During de-ballasting sodium sulfite is added to the suction side of the de-ballasting pump which instantly reacts and neutralizes residual oxidants. The processes are recorded in a data log and can easily be downloaded by authorities to confirm successful treatment.

Manufacturer: Severn Trent De Nora, LLC, Germany

Link/Reference: www.balpure.com

Approval Status: Final Approval for Active Substances, October 2010