IHS **Maritime**

Guide to ballast water treatment systems 2013

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Introduction

> The waiting game continues as the IMO looks for a further 6% of the world's tonnage to ratify the Ballast Water Management Convention. IMO secretary-general Koji Sekimizu said in February at the subcommittee on bulk liquids and gases that he had a "serious concern that, more than eight years after its adoption, the conditions for entry into force have not yet been met".

Systems' performance standards have been cited as one reason why many significant maritime nations have yet to ink this convention and, acknowledging this, Sekimizu added: "I urge the subcommittee to contribute to this effort by finalising the draft circular on ballast water sampling and analysis."

Exactly when it will come into force remains to be seen, but that day will arrive and when it does the rush for retrofits will difficult to accommodate in yards.

You could argue that operators and owners should act now and get a ballast water management system (BWMS) installed. Yard space is available and there are likely to be good deals from system providers keen to oblige early purchasers with a reduced price. But there are a number of systems still being tweaked as they aim for type-approval. If they receive this, there will be more choice.

Either way it's never too early to start considering which system would be the best fit for your vessel and there are now enough different systems out there to get an overview of what's likely to be available in the long term. Size and configuration, ease of use, maintenance requirements and, of course, type-approval status are always going to be the most important considerations (see page 43).

There are now a number of manufacturers that have a variety of systems available (see pages 14-42), many developed with specific types of vessel in mind. More than 40 of these are listed in this guide. ■

> Approved or type-approved?

Don't get the two confused. IMO's G9 standard refers to systems that use active substances. These substances have to be 'approved' by the IMO. Final approval can only be received following the successful completion of tests at a shore-based centre and under operational conditions.

The G8 standard refers to systems that don't use active substances.

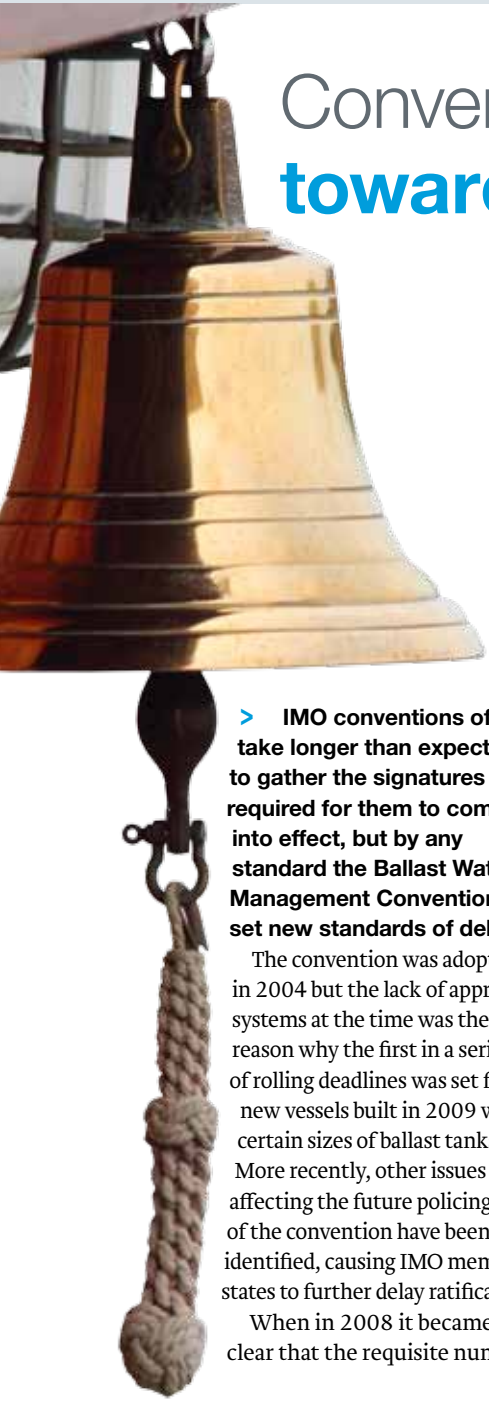
Both G8 and G9 systems have to be 'type-approved' according to IMO specifications by member states before they can be operated in the individual member states' waters. Classification societies are usually appointed to issue type-approvals on behalf of the member states. Eventually these type-approvals are rubber-stamped by the IMO.

D1 is the ballast water exchange, rather than treatment, standard.

D2 is the standard that dictates the newbuilding and retrofitting of ballast water treatment systems, which must be type-approved and capable of meeting a cleaning standard that results in fewer than 10 viable organisms/m^3 if the organisms are 50µm or larger, or 10 viable organisms/ml if they are smaller than 50µm.

The G4 standard covers the development of a ballast water management plan that all ships will be required to carry.

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Convention timeline: towards the last lap

> IMO conventions often take longer than expected to gather the signatures required for them to come into effect, but by any standard the Ballast Water Management Convention has set new standards of delay.

The convention was adopted in 2004 but the lack of approved systems at the time was the main reason why the first in a series of rolling deadlines was set for new vessels built in 2009 with certain sizes of ballast tanks. More recently, other issues affecting the future policing of the convention have been identified, causing IMO member states to further delay ratification.

When in 2008 it became clear that the requisite number of signatures was not going to be achieved, the IMO decided on a one-year extension for the first tranche of affected vessels but, despite pressure from the industry, it has not, so far, agreed any further concessions. There are now 36 signatories to the convention, with only 30 required, but this represents only 29% of world tonnage, while 35% is required. Ballast water treatment systems are not cheap, can be demanding of space and, depending upon ship size and the technology involved, can add unwanted weight to the vessel. It is therefore not surprising that in the depth of a recession few owners have bothered to take the plunge and install a system to comply with a convention that has no legal force.

As a result, a backlog of more than four years of newbuildings that have ignored the requirement to have a system fitted on delivery has built up. Even if the final signatures needed on the convention are added later this year, there is still a one-year lead-in time, so it will be more than five years after the IMO's planned deadline before that first cohort of vessels is obliged to comply. If some degree of leeway is not agreed before the convention is ratified, an intended nine-year programme will be telescoped into four.

Fight for yard space

It is beginning to dawn on the industry and regulators that this will be a major hurdle to overcome. The years since 2009 have all set records for ship production. So even allowing for the fact that the largest vessels, with ballast capacities above 5,000m^3, were exempt until

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2012, there are likely to be more than 10,000 vessels below four years of age built without systems. When the convention is eventually ratified, all of those will be joining the ranks of vessels built before 2009 and jostling in the queues for systems and looking for yard space for retrofits.

The main reasons for the lack of signatures on the convention is that a significant number of major flags have listened to national shipowners associations' concerns that type-approved systems may not meet discharge standards under all operational conditions. Of the major flags only Liberia, the Marshall Islands, Norway, and France have signed; Panama, Japan, China, and India, along with most European nations, have held back.

To become type-approved, a system must

> Identifying the deadline

Table 1 below, showing the dates for ships to switch from DI (ballast water exchange) to D2 (treatment systems), is as released by the IMO, but for some reason many find it difficult to interpret because the actual date for any given ship will vary, depending on a number of factors.

To help the confused, Germanischer Lloyd has devised a means of assistance. The tool is the GL BWM Calculator, which enables owners to easily calculate the due date of compliance with the D2 treatment standard for any vessel. This is based on the construction date and the size of vessel – measured by ballast water capacity – and covers both vessels in service and newbuildings. The calculation requires only a minimal amount of input and produces a clear illustration of a vessel's individual timeline for compliance, suitable for fleet records. Because there is a plus/minus three-month period for scheduled surveys to be done, owners can work with system makers and drydocks to find a suitable time in the six-month window.

> The calculator is open to all and is available at:
https://app.gl-group.com/webapp/bwm_home.do

Table 1: IMO Ballast water treatment compliance schedule

Ballast capacity (m^3)	Construction date	First intermediate or renewal survey, whichever occurs first after the anniversary of the date of delivery in the year indicated below								
		2009	2010	2011	2012	2013	2014	2015	2016	2017
< 1,500	< 2009	D1 or D2								D2
	≤ 2009	D2								
≥ 1,500 or ≤ 5,000	< 2009	D1 or D2						D2		
	≤2009	D2								
> 5,000	< 2012	D1 or D2								D2
	≤ 2012	N/A			D2					

> US overcomes divisions to take a lead

Even before the IMO convention was adopted in 2004, individual states in the US had threatened to enact local regulation to combat the problem of invasive species, with California and New York being particularly vociferous. In an attempt to bring all the states into line, the US federal authorities began to formulate rules that would apply throughout the country.

Delays in implementing the new standards once again led individual states to begin the process of implementing individual standards. The US Environmental Protection Agency (EPA) was told by federal authorities not to rubber-stamp these state standards and in late 2011 set about formulating a final rule, which was approved in 2012 and becomes effective in December this year. The US Coast Guard's (USCG's) final rule includes a review of the practicability of implementing a future higher, more stringent, ballast water discharge standard. The review result is set to be published before 1 January 2016.

These US rules will be administered by the EPA and USCG. They are contained in USCG Regulations 33 CFR (Code of Federal Regulations) Part 151 and 46 CFR Part 162 and will apply to all ships constructed after December 2013 and to existing ships from 2014 onwards (see table 2).

Ships intending to discharge ballast must either exchange or treat ballast, as well as carrying out fouling and sediment management. Ballast exchange, as with the IMO convention, will only be allowed until the treatment systems deadlines come in to force. Ships can also use potable (drinking) water from the US public water system.

Ballast systems do, however, have to be approved by the USCG and it may be the case that these do not match those that are IMO-approved, although the USCG treatment discharge standard is the same as the IMO Ballast Water Management Convention D-2 Standard.

Type approval by the USCG is not expected to be any more difficult to obtain than it would be in other jurisdictions but until USCG approval is given, operators should understand that the certificates currently on their ships are

adhere to one or two sets of guidelines laid down by the IMO. There are, in fact, several more guidelines connected with the convention, but the two commonly referred to as G8 and G9 deal with with approving systems.

G9 is concerned with 'active substances' – a system that achieves the desired kill rate of organisms in the ballast water and ensures that, when the water is eventually discharged, there is nothing in it that will present a danger to local marine life. The G8 guideline covers the type-approval of all systems and involves a series of shore and shipboard tests of the prototype system. As the number of type-approved systems has grown, some have been found to operate at lower efficiencies, or not at all, in certain environmental conditions.

The IMO has decided not to reopen the G8 type-approval guidelines but has asked the Bulk Liquid and Gases (BLG) subcommittee of the Marine Environment Protection Committee (MEPC) to look into the associated certification guidance with the aim of clarifying the conditions in which systems are expected to operate. Factors to be considered include seawater salinity, temperature, and sediment load, as well as operation with a significantly lower than rated treatment flow rate.

A decision reached at the BLG17 meeting in early February may provide the final push

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effectively worthless. If an operator plans to trade regularly to the US, a decision needs to be made about whether to present the system on the ship for individual approval or to press its maker to apply for blanket type approval.

The system manufacturer must apply to the USCG for approval and must ensure that the equipment is tested by an independent laboratory. As things stand, no independent laboratory has yet been approved by the USCG, although this is sure to change during the year.

A US Shipboard Technology Evaluation Program (STEP) is in place and operators and system makers may find it of value. The programme aims to give makers an opportunity to prove the effectiveness of their products under operational conditions and gives dispensation to systems that are participating in the programme. Concessions include giving systems accepted by the programme a 10-year period during which they will be considered as meeting the discharge standards.

A small number of US-made systems have been participating in the programme since before the new discharge rules were set and vessels with these systems are considered as compliant for the life of the vessel or the life of the system.

Table 2: USCG's schedule for treatment system implementation

Source: USCG

	Vessel's ballast water capacity	Date constructed	Vessel's compliance date
New vessels	All	On or after 1 December 2013	On delivery
Existing vessels	Less than 1,500 m^3	Before 1 December 2013	First scheduled drydocking after 1 January 2016
	1,500-5,000 m^3	Before 1 December 2013	First scheduled drydocking after 1 January 2014
	Greater than 5,000 m^3	Before 1 December 2013	First scheduled drydocking after 1 January 2016



Delmar Hasenpusch

needed for the convention to come into force. With about 40 ballast water treatment systems already fully approved and at least a further 20 in the early stages of approval, it is generally accepted that there is no longer any reason to delay on the grounds of number of approved systems. The fact that the US authorities have already initiated a federal requirement for ships operating in US waters is testament to this.

Consistent performance standards

Now the main hurdle for the IMO convention is the divergence of performance standards required for systems to become type approved and the possible testing and sampling methods and standards of port state control (PSC) inspections. At BLG17, IMO member states agreed on a proposal that would see a two-year trial period for PSC sampling and analysis methods to take place once the convention comes into force.

Under the terms of the proposal, PSC inspections will only result in a detention if a system's certification or the necessary ballast water management documentation is not in order. If a system is tested and the sample is found to contravene the requirements of the convention despite the system having been operated correctly and proper records made, no action will be taken by PSC. This approach is similar to that of the US authorities.

At the end of the two-year trial period, the IMO will conduct a review to determine which methods of PSC sampling should be permitted and amend the sampling and analysis protocols of the convention accordingly. The proposal has been referred to the MEPC for possible adoption at MEPC65 in May this year. The IMO also asked member states to submit case studies with quantitative evidence of system failures to improve understanding of areas of weakness within the approval process.

Several bodies within the shipping industry have welcomed the attempt to bring PSC and the type-approval process back into sync and are now focusing their efforts on dealing with the logjam of retrofits that is expected when the convention comes into effect.

At present the proposal favoured by the leading bodies is to define existing ships as those constructed prior to the convention coming into force, and that retrofitting of type-approved systems should not be required until the next full five-year survey, rather than the next intermediate survey. As yet the IMO has not indicated whether it is prepared to accept that proposal but, if to do so would remove the final obstacles to full ratification, then it is likely that the organisation's often-expressed desire to see the convention in place may override its objections. ■



Even if the convention gets enough signatories this year it will still be more than five years after the IMO's planned deadline before the first vessels are required to have a system fitted

National Ballast Information Clearinghouse at SERC

How systems work

> The technology used to treat ballast water has generally been derived from other industrial applications, such wastewater treatment systems, in which forms of solid-liquid separation and disinfection processes were applied.

The separation process concerns the removal of solid suspended material from the ballast water by sedimentation or straining by means of a filter. This produces a waste stream that comprises backwash water from the filtering or a hydrocyclone operation. The waste stream is discharged during ballasting.

Disinfection may be achieved in a number of ways. Chemical treatment uses oxidising biocides that interfere with the micro-organism's organic structure or non-oxidising biocides that interact with reproductive or metabolic functions. Physico-chemical treatment systems use UV light, heat or cavitation. Deoxygenation is another method, in which the organism is asphyxiated.

There are three fundamental ballast water treatment technologies, which are generally combined within one system. These are mechanical, which consists of filtration or cyclonic separation; physical disinfection, comprising ultrasound, ultraviolet (UV) radiation, heat, cavitation, deoxygenation, and coagulation; and chemical treatment and biocides, comprising electro-chlorination, ozonation, chlorination, chlorine dioxide, and advanced oxidation.

Most systems employ a two-stage approach involving mechanical separation at the first stage, followed by a second-stage physical/chemical treatment. At this stage some systems use a combination of two or more treatments.

Operational implications, extended ballasting time as a result of pressure drops, consumables needed, and energy requirements all need to be assessed (see

> Treatment technology type and symbol

Mechanical

1. Cyclonic separation (hydrocyclone)
2. Filtration



Chemical treament and biocides

1. Chlorination
2. Chloride dioxide
3. Advanced oxidation
4. Residual control (sulphite/bisulphate)
5. Peraclean Ocean



Physical disinfection

1. Coagulation/ flocculation
2. Ultrasound
3. Ultraviolet
4. Heat
5. Cavitation
6. Deoxygenation
7. Electro-chlorination/ electrolysis
8. Electro-catalysis
9. Ozonation`



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page 43). Shipowners and operators should condider the design of the ballast system pipe layout as some systems make use of components that can be placed at various locations around the ship.

For those systems that use active substances to treat micro-organisms, sufficient stocks of those substances will have to be carried on board to satisfy the number of units installed and the frequency and quantity of ballast operations.

Those that use the effect of UV on water or the properties of seawater to generate electric currents to generate active substances, do not require carriage of further substances.

IHS Maritime compares the various technologies, each of which has its own symbol as shown in the key below.

A description of each of the systems that appears in Table 3 is also provided, designated with the symbol for its technology type.

Disinfection by-products are an issue, and this is central to the approval of systems that employ an active substance. Generally, these systems treat on uptake only, with the exception of those that use neutralising agents before discharge. ■

> Physical, mechanical or chemical?

Solid-liquid separation

The filtration process uses discs or fixed screens with automatic backwashing and is generally effective for larger organisms and particles. The low membrane permeability means surface filtration is not practical, so backwashing is required to maintain flow because of the pressure drop.

As a means of removing larger particles, hydrocyclones are a good alternative. These separate the particles through high-velocity centrifugal rotation of the water.

Both filtration and cyclonic separation can be improved by pre-treatment in the form of coagulation, but this needs extra tank space and an ancillary powder to generate the flocs.

Oxidising biocides

When diluted in water, chlorine destroys cell walls of organisms, while electro-chlorination creates an electrolytic reaction using a direct current in the water. Both methods are well-established municipally and industrially, but are virtually ineffective against cysts unless a concentration of at least 2mg/litre is used.

Ozone gas, which is bubbled through the water, is effective at killing micro-organisms. It produces a bromate by-product and requires an ozonate generator.

Chlorine dioxide is effective, particularly in high-turbidity waters. It has a half-life of 6–12 hours but, according to suppliers, can be safely discharged within 24 hours.

Physical disinfection

When ultraviolet irradiation is used, amalgam lamps surrounded by quartz sleeves produce UV light, which changes the molecular structure of the organism and thereby prevents it from reproducing.

The deoxygenation method relies on reducing the pressure of oxygen in the space above the water by injecting an inert gas or inducing a vacuum. The removal of oxygen may also lead to a reduction in corrosion.

If heat is employed to treat the ballast water, the water can be used to provide engine cooling while being disinfected.

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Systems update

PureBallast
Alfa Laval



> **Pure Ballast was one of the first** systems to be approved and uses UV to produce hydroxyl radicals that destroy cell membranes. It is based on Advanced Oxidation Technology (AOT) developed initially by Wallenius.

At the system's heart are UV lamps housed in modules of 24. The system is scalable by the addition of extra modules as required. Modularity can help where space is at a premium, as the units need not all be housed in one space.

During ballasting and deballasting, the units create radicals with the help of a catalyst and a light source. These radicals then destroy the cell membrane of micro-organisms. The radicals, which never leave the unit, have a lifetime of only a few milliseconds and pose no risk to the environment or crew.

During ballasting a 50µm filter removes larger organisms, leaving only the smallest to be treated. The system also operates when deballasting as a safety measure to kill any organisms that may have survived the initial treatment. In deballasting the filter unit is bypassed.

PureBallast precisely logs starts, stops and other data in accordance with IMO guidelines.

Now in its second generation, PureBallast 2.0, operation of the system can be suspended for short intervals and individual AOT units can be shut down to allow changes in flow rate, without affecting treatment. This version has an improved graphical user interface.

An explosion-proof version of the system exists. PureBallast 2.0 EX is designed for use in zone 1 hazardous areas in accordance to the IEC 60079 series of standards, explosion group IIC and temperature class T4 (135°C).

AquaStar
Aqua Engineering



> **The AquaStar BWM system has been** developed by Aqua Engineering of Busan, South Korea, and has been granted basic and final approval for the active substance used and type approval from Korea authority. It is available in 10 models, from small to large systems, for different vessel types and sizes. Five of them have ex-proof certificates.

The process starts with the use of the use of a 'smart' pipe (Korea patent) and treatment with the active substance sodium hypochlorite, which is formed in-situ by electrolysis of seawater in the ballast water main pipe. This physically affects aquatic organisms larger than 50µm.

The second stage of the process consists of four independent in-line electrolyser units. Each can be arranged independently, vertically or horizontally. The electrolyser is controlled from an integrated automatic control system unit, which has a master and local control unit and incorporates the ballast pump.

The flammable hydrogen gas is taken out of the vessel through a gas separator system.

Total residual oxidants are neutralised by controlled injection of sodium thiosulphate from a neutralisation unit during deballasting.

The AquaStar system does not include a filtration process, which the company claims should do away with clogged systems and cleaning and replacement of elements.

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Anolyte - KP
Atlas-Danmark



> **Named after the disinfecting agent it** uses – a biocide mixture – this system also uses filtration and a reducing agent, known as Catolyte. Atlas-Danmark describes the Anolyte disinfection agent as "electrochemical activated water", which contains a mixture of reactive molecules and meta-stable ions and free radicals. The company says the disinfection agent destroys itself during the disinfection process, thereby ensuring that the environment and the crew are not endangered.

The Anolyte is taken from available tanks or those built into the vessel and is injected into the ballast water treatment system (BWTS) by a dosing pump that can be located anywhere between the storage tank and the ballast water intake connection. The electrolytic cells used in the BWTS act as the Catolyte reducing agent. During the process, the Catolyte is fed directly to one or more of the ballast tanks. After the Anolyte disinfection, the Catolyte is said to slightly increase the pH value and corrosion resistance in the ballast water tanks.

Ozone and other compounds in the Anolyte are injected during natural flow of the ballast pumps and filters. When added to the filtered ballast water, all micro-organisms are reportedly killed within a few seconds.

By using a self-cleaning, pre-filtration filter of less than 50µm, the Anolyte portion is reported to be substantially reduced, depending on the filter size.

CrystalBallast - KP
Auramarine



> **The CrystalBallast treatment system** from Auramarine is based on a two-step process, with an automatic filter to remove sediment and larger organisms followed by an intensive medium-pressure UV unit to disinfect and destroy smaller plankton, bacteria and pathogens.

The use of automatic filtration enables the treatment dose to be reduced, leading to savings in energy. All organisms and particles removed by the filter are continually returned to the sea at the ballasting site. The second step, CrystalBallast ultraviolet light disinfection, is fully chemical-free. With chemical-free operation you can be sure that there is no risk of additional corrosion or tank coating damage.

Ballast water is treated using the complete process during intake and re-treated during discharge through the UV reactor only. Re-treatment during discharge is necessary to eliminate possible regrowth of bacteria in ballast tanks due to cross contamination.

The CrystalBallast Active Flow Control (AFC) system keeps the flow within the overall system's maximum rated treatment capacity. The AFC also ensures that there is adequate counter pressure for the filter during the cleaning cycles. The flow data from the AFC system is logged in the control system memory along with the UV treatment intensity information.

CrystalBallast systems offer advanced automation with cross communication with existing vessel systems. High-quality duplex materials for the filter screen and UV-reactor give the system a long lifetime in the extremely corrosive environment of ballast water. CrystalBallast is a scalable system, with standard versions from 75m³/h to 1,500m³/h. All standard versions are available in both factory tested skid-mounted modules and as modular retrofit kits. Retrofit engineering, supervising and installation services are also available through Auramarine.

CrystalBallast BWT systems have passed the

stringent verification of DNV to achieve type approval. Auramarine also has ISO 9001 and ISO 14001 certificates, proving its dedication to high-quality products.

Bio-Sea
Bio-UV



> **Bio-UV's Bio-Sea system was** developed in France and uses filtration and UV. It has been approved according to IMO G8 guidelines.

First the system cleans the ballast water using a 40µm filtering element in order to retain suspended solids and zooplankton. The system is modular and scalable in size from 50 to 2,000 m^3/h, or higher upon request. The filter size will be dependent on the system size according to the ballast pump flow rate. Bio-UV offers a choice of two filter types. The filter is equipped with automatic backflushing controlled by a pressure switch. There is no disruption of the filtration process during the cleaning cycle and no significant variation in the treated flow rate, says the company.

The UV stage of the treatment takes place in a reactor with a single polychromatic, medium-pressure, high-intensity UV lamp housed in a protective quartz sleeve. Sensors monitor and control the intensity of the UV. On larger systems, more of the reactors are installed in parallel, allowing for better tuning of the flow rate. Treatment with UV also takes place at discharge.

The system features a control module with touch screen. Control can be exercised manually or programmed for fully automatic treatment, says the manufacturer. Data on all operations is logged and stored for two years.

Bio-UV has 14 years of experience in designing and manufacturing UV water treatment systems for drinking water.

Cathelco BWT
Cathelco



> **The Cathelco BWT system is based on** a combination of filtration and UV technology. The units are available with capacities from 50m^3/hr to 2,400m^3/hr or up to 1,200 m^3/hr per single system.

During ballast water uptake the seawater passes through the filtration unit, where large organisms and sediments are removed. These are automatically backflushed at the original ballasting site. The seawater then undergoes UV treatment, where smaller organisms, bacteria and pathogens are rendered harmless.

Each UV chamber has two lamps and specially designed inlet pipework that causes the water to flow along in a helix formation. The company says this ensures the maximum surface is exposed to the UV light, increasing the efficiency of the process. The twin-lamp design results in very compact chambers, claims the company.

To maintain effectiveness in different water conditions, UV transmittance sensors monitor the sediment and automatically adjust the power to the lamps. UV intensity meters measure the lamps' performance, indicating when they need to be replaced. Another feature is the foam ball cleaning system, which is said to remove residue from the quartz tubes without the use of chemicals.

The Cathelco BWT system will be launched in 2Q/2013.

Gas Lift Diffusion
Coldharbour Marine



> **Specifically designed and optimised for** large tankers, LNG/LPG carriers and bulkers, UK-based Coldharbour Marine's Gas Lift Diffusion (GLD) system operates 'in-tank'

rather than 'in-line'. Flow rates are irrelevant, as ballasting continues as normal, so there are no filters to block or backflush, no pressure drops and no additional power requirements.

The Coldharbour GLD system uses the inert gas output from the Coldharbour Sea Guardian inert gas generator (IGG), which is linked to specially designed GLD pipe assemblies mounted inside the ship's ballast tanks. Sea Guardian is designed to generate ultra-clean, very-low-oxygen inert gas and, according to the company, is compact and largely maintenance-free.

During a portion of the voyage, the output from the IGG is pumped by standard marine compressors to the GLD units inside the ballast tanks where the treatment takes place.

The GLD units use natural fluid dynamics to both thoroughly stir the ballast tanks and diffuse the inert gas into the water. Untreated water is drawn into the GLD assemblies from the base of the ballast tank and, as the inert gas diffuses into the water through the GLD unit, oxygen is stripped from the water. Meanwhile, the elevated level of $C0_2$ in the inert gas temporarily reduces the PH level of the water. This simultaneously induces hypoxia and hypercapnia. These conditions are fatal to both aerobic and anaerobic marine organisms.

To effectively kill the remaining organisms (E Coli bacteria for example) there is a patented method of micro bubble generation and gas-induced ultrasonic shockwaves, produced inside the GLD.

System performance is not affected by normal silt and solid levels within the ballast tanks or even changes in salinity or temperature. The GLD assemblies have no moving parts and as such are 100% reliable, the company claims.

The Coldharbour Marine GLD ballast water treatment system is of the G8 type, as defined by the IMO. The system is under the flag state approval of the UK Maritime and Coastguard Agency (MCA) - Lloyds Register (UK).

The system is completing land-based testing and is currently undergoing sea trials on board a VLCC.

The final approval certificate is expected to be awarded during 4Q/2013.

Blue Ocean Shield COSCO



> **Blue Ocean Shield (BOS) is a** modularised ballast water treatment system, designed and developed by China Ocean Shipping Company (COSCO) Shipbuilding together with Tsinghua University.

The BOS system can run in different configurations, depending on the level of treatment required and the particular properties of the ballast water, by employing filtration and UV and introducing a hydrocyclone if required.

The system operates in-line during the uptake and discharge of ballast water. Before UV treatment takes place, a filter system reduces the sediment load of the ballast water, in addition to removing some micro-organisms. The filtration system is installed on the discharge side of the ballast water pumps and is fully automatic in terms of its cleaning operation. The UV unit employs high-output, low-pressure ultraviolet (LPUV) lamps to destroy living micro-organisms present in the ballast water.

Ballast water is treated at intake and again at discharge. The treatment on intake ensures that a minimal amount of viable organisms enter the ballast water tanks and reduces sediment build-up in the tank. The water is treated again at discharge only by the UV system to ensure that the potential regrowth of organisms in the ballast water tanks is decreased as much as possible.

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Cyeco BWMS
Cyeco



> **The Cyeco BWMS features a two-stage** process: efficient self-cleaning filtration to remove larger organisms and sediments, followed by powerful medium-pressure UV to disinfect and inactivate smaller plankton, bacteria and pathogens.

The process is chemical-free and so avoids the update or discharge of organisms but does not generate toxic substances that can be harmful to the environment or human health or cause corrosion to the system.

The patented high-pressure backflushing mechanism keeps the four-layer filter screen clean and provides reliable, non-stop operation at high sediment loads, says the company.

It explains that the system's high pressure backflushing mechanism is able to handle ballast water with an extremely low inlet pressure of 1 bar, and the head loss is less than 0.2 bar in total.

The system is said to be compact in design, easy to install and requires very little maintenance. Since it received its type approval certificate, followed by IMO acceptance, the Cyeco BWMS has been installed and operated in a variety of vessels.

OxyClean
Desmi Ocean Guard



> **The OxyClean system from Desmi** Ocean Guard consists of three treatment steps, according to the company. First, a filtration unit removes particles, zooplankton and large algae, and comes range of sizes from 64m³/h to 3,000m³/h.

The filter is pressurised, has automatic backflushing and is fitted with a 30µm pore-size mesh to remove particles. This filtration process enables the following distinfection step to be more efficient.

In the second step, water flows through the UV unit and is thereby exposed to a high dose of UV-C (short-wave ultraviolet) irradiation from low-pressure UV lamps to deactivate the remaining organisms. The company claims that each unit is capable of treating 100m³/h of ballast water in salt and brackish water conditions, and 75 m³/h in freshwater conditions.

The UV unit also generates ozone, which is used in the third step of the treatment process. Water passes through a venturi injector and the vacuum created sucks dry compressed air through the ozone-generating UV-unit via a pipeline to the injector for mixing into the main ballast water stream.

Finally, the treated water is directed to the ballast tanks. The full three-step treatment is repeated during deballast. The system has passed IMO testing in all three salinities: salt, brackish and freshwater.

The system is controlled via a touch screen and mimic pictures, which provide an overview of the system. It automatically logs all events and alarms.

The system is type approved by Lloyd's Register for flow rates between 75 and 3,000m³/h. ABS has issued a design assessment certificate for the system, and DNV has conducted a safety assessment and concluded that the system met its class requirements for safety.

ES
Ecochlor



> **Ecochlor is a US company that uses** the patented Purate ClO_2 technology, which was specifically designed to safely eliminate

the transfer of aquatic invasive species. Its BWMS uses filtration, followed by the water purification treatment – a small amount of supply water flows through a venturi injector creating a vacuum that draws the Purate and acid into the mixing chamber. When the chemicals combine they form a dilute aqueous ClO_2 solution, which is then injected into the ballast water.

The company says that the combination of filtration to 50µm and treatment with 5ppm of ClO_2 makes it effective on all organisms regardless of temperature, salinity, suspended solids or turbidity, and organic loading. The Ecochlor BWMS, with the exception of the filters, can be placed almost anywhere on the vessel.

The product's technology is best suited to vessels with high ballast water pump capacities because of the low power requirement, flexible configuration and size advantage, and ease of installation, says ES.

The Ecochlor IMO type approvals include systems capable of treating up to 16,000m³/h, it says. Type approval was granted to the Ecochlor system on 8 November 2011 by the Federal Maritime and Hydrographic Agency (BSH) of Germany.

Ecochlor's technology was also one of the first accepted into US Coast Guard's (USCG's) STEP programme and the application for approval as an alternative management system (AMS), under recent guidelines by published by the USCG, has been submitted.

BlueSeas and BlueWorld Envirotech



> Envirotech's BlueSeas and BlueWorld also make use of use filtration (50µm), seawater electrolysis and sodium thiosulphate neutralisation treatment upon uptake.

Its maker claims the system is energy-efficient and compact. With a smaller onboard footprint and lower energy consumption, the BWMS is expected to appeal to shipowners that need to discharge high volumes of ballast water in a short period of time using a compact system.

Erma First BWMS Erma First ESK



> Developed by Erma First ESK Engineering Solutions of Greece, the Erma First BWTS is described as a robust integrated system with low energy consumption and a small footprint. It consists of individual modules, each with a treatment capacity of 100m³/h. Hydraulic parallel connection of the modules result to treatment capacity up to 3,000m³/h.

Treatment is in two stages. First, suspended materials and larger organisms are removed by means of pre-filtration and an advanced cyclonic separator. Then, during ballasting, electrolysis is used to generate active chlorine. Here, residual oxidants disinfect any harmful organisms that may have been taken on board.

The levels of chlorine are controlled so that even in waters where suspended sediment is high, the efficient cyclonic units ensure low chlorine demand for the disinfection of the micro-organisms. In addition, the electrolysis cell's special coating ensures sufficient chlorine concentration.

During deballasting, residual chlorine is neutralised by the addition of sodium bisulphite solution. Great emphasis has been placed on monitoring and control to ensure proper operation and effective neutralisation of treated ballast water prior to discharge to

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sea. The control unit logs the status of the system, operation, electrolytic cell, self-cleaning filter and cyclonic separator.

The Greek administration granted type approval to the system in May 2012. Class approval has been obtained from Lloyd's Register.

Erma First, in co-operation with a US consultant, is preparing a US Application for alternate management system designation as well as USCG approval.

BallastMaster
GEA Westfalia



> **The BallastMaster ultraV system is** an efficient mechanical and physical ballast water treatment system designed for salt, brackish and freshwater, according to manufacturer GEA Westfalia.

It can also handle a high concentration of organisms and sedimentary particles.

Type approved in 2011 by the BSH (Bundesamt für Seeschifffahrt und Hydrographie), the system complies with the IMO's D2 standard.

The layout of the UV chambers has been designed to achieve the most effective disinfection efficiency, says the company. The BallastMaster ultraV operates during ballast water intake and discharge.

During both of these processes, the water is treated in a two-step process. This consists of pre-filtration and LP-UV low-pressure ultraviolet disinfection without any use or generation of unwanted by-products such as radicals.

All parts that are in contact with ballast water are made out of stainless steel, and the system is fully automated without any attention required by the operator.

In the first stage a mechanical filtration process upstream removes all organisms and sedimentary particles larger than 20µm. This prevents sedimentary deposits accumulating in the ballast water tanks. The filter modules are cleaned automatically by vacuum extraction.

In the second stage a disinfection by LP UV-C+ radiation takes place.

A monochromatic UV-C radiation (254NM) disinfects organisms such as bacteria and phytoplankton effectively.

Aquarius
Hamworthy/Wärtsilä



> **The Wärtsilä Aquarius BWMS uses two** treatment technologies, UV and electro-chlorination (EC), and became part of the Wärtsilä portfolio following the acquisition of Hamworthy in January 2012.

The Aquarius UV BWMS follows a two-stage process, with filtration followed by disinfection using ultraviolet light, and does not use any active substance. At discharge the filter is bypassed and water from the ballast tanks is pumped through the UV chamber, where it is treated before being discharged overboard.

The Wärtsilä Aquarius UV BWMS development is based upon validated filtration and UV technologies to ensure performance in all water conditions. The system has been fully tested and successfully completed land-based and shipboard trials in accordance with the IMO G8 protocols including efficacy assessment in fresh, brackish and seawater conditions. The system operation is fully automated and allows for flexible integration with ship systems.

There are two product variants; one for safe area installation and the other, currently

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in development, to facilitate installation in hazardous areas.

The Wärtsilä Aquarius EC BWMS employs a two-stage approach with filtration on BW uptake followed by disinfection using in-situ side-stream electro-chlorination. Upon de-ballasting, the system neutralises any remaining active substance using sodium bisulphite, ensuring that the ballast water can be safely discharged back to the sea.

The Aquarius EC achieves filtration using automatic backwashing screen filter technology. Designed specifically for ballast water applications, this filters particles down to 40µm, says the company. Operation of the filter includes automatic backwashing to ensure efficient removal of particles that are discharged back to the environment of origin; the systems are PLC-controlled, with touch-screen operation. All relevant data is stored by the programmable logic controller in line with IMO requirements and the system can be fully integrated into the main control system to achieve complete ballast water management on board ship.

Eco-Guardian
Hanla IMS



> Hanla IMS is about to launch its first BWMS called Eco-Guardian. The system, which uses indirect electrolysis, complies with IMO D2 discharge standard, says the company. It is composed of a filter unit, electrolysis unit and neutralisation unit.

According to the company, it can be easily installed on a new ship or as a retrofit. Hanla IMS says it is easy to operate, has a low maintenance cost, is effective in turbid water, does not require stocks of dangerous chemicals and carries out sediment removal on site.

OceanGuard
Headway Technology Co



> The OceanGuard Ballast Water Management System was researched and developed by Headway Technology and Harbin Engineering University. The system has obtained IMO final approval, CCS type approval and DNV type approval on behalf of the administrations, while USCG approval is ongoing.

OceanGuard BWMS uses the Advanced Electrocatalysis Oxidation Process (AEOP), which is unique to the system. The company says it offers high and complete sterilisation, performance in freshwater and seawater, and no corrosion or secondary pollution. It is said to have a compact design and small footprint.

The AEOP produces short-lived hydroxyl radicals. The organisms are transformed to simpler organic molecules that are eventually mineralised to CO_2, H_2O and trace inorganic salt.

OceanGuard has three main components. The control unit contains the procedures for system operation. It has system diagrams and sensor displays and is used for monitoring and regulating data readings and dealing with any alarm signals.

A fully automatic 50µm backflush filter, which can accomplish automatic backflush and filtering at the same time, prevents large organisms from entering the ballast tank to reduce sedimentation.

An EUT (electro-catalysis enhanced by ultrasonic treatment) unit consists of two parts: an electro-catalysis unit to produce the oxidising substances and an ultrasonic unit that self-cleans the EUT unit. In July 2011 Headway Technology reached a co-operation agreement with Italian cruise company Costa Crociere, followed by agreements with a Greek oil tanker shipping company and Norwegian multipurpose vessel company.

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Table 3: Current approval status of ballast water treatment systems

Manufacturer and system name	Active substance	Substance approved by IMO	Type approved	Website
Alfa Laval (Pureballast)	yes	final	yes	www.alfalaval.com
Aalborg/Aquaworx (AquaTriComb)	no	n/a	no	www.aquaworx.de
Aqua Engineering (Aquastar)	yes	final	yes	www.aquaeng.kr/eng
Atlas-Danmark (Anolyte)	yes	no	no	www.atlas-danmark.com
Auramarine (Crystal)	yes	yes	yes	www.auramarine.com
Bio-UV (Bio-Sea)	no	n/a	yes	www.ballast-water-treatment.com
Cathelco	no	n/a	no	www.cathelco.com
Coldharbour Marine	no	n/a	no	www.coldharbourmarine.com
COSCO (Blue Ocean Shield)	no	basic	yes	www.cosco.com.cn
Cyeco	no	n/a	yes	www.cyecomarine.com
Ocean Guard Desmi (OxyClean)	yes	final	yes	www.desmioceanguard.com
Ecochlor	yes	basic	yes	www.ecochlor.com
Envirotech (BlueSeas)	yes	basic	no	
Envirotech (BlueWorld)	yes	basic	no	
Erma First ESK Engineering Solutions	yes	final	yes	www.ermafirst.com
GEA Westfalia (BallastMaster)	yes	basic	yes	www.westfalia-separator.com
Hamworthy/Wärtsilä (Aquarius EC)	yes	basic	no	www.hamworthy.com
Hamworthy/Wärtsilä (Aquarius UV)	no	n/a	yes	
Hanla IMS (Eco-Guardian)	yes	basic	yes	http://hanlaweb2.bluemarinesys.gethompy.com
Headway Technology Co (OceanGuard)	yes	final	yes	www.headwaytech.com
Hitachi (ClearBallast)	yes	final	yes	www.hitachi-pt.com
Hyde Marine (Guardian)	no	n/a	yes	www.hydemarine.com
Hyundai HI (EcoBallast)	yes	final	yes	english.hhi.co.kr
Hyundai HI (HiBallast)	yes	final	yes	english.hhi.co.kr
JFE Engineering (BallastAce)	yes	final	yes	www.jfe-eng.co.jp

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Manufacturer and system name	Active substance	Substance approved by IMO	Type approved	Website
Kuraray (MicroFade)	yes	final	yes	www.kuraray.co.jp/en/
Kwang San (En-Ballast)	yes	basic	no	www.kwangsan.com
Mahle NFV (Ocean Protection)	no	n/a	yes	www.mahle.com
Maritime Assembly Systems (BAWAC)	no	n/a	no	www.mas-wismar.com/en/
MH Systems	no	n/a	no	www.ballastwatersolution.com
Mitsui Engineering (Special Pipe Hybrid – Ozone)	yes	final	no	www.mitsui.com.jp/en/
NEI Treatment Systems	no	n/a	yes	www.nei-marine.com
Nutech O3/NK Co (BlueBallast)	yes	final	yes	www.nutech-o3.com
OceanSaver Mark I	yes	final	yes	www.oceansaver.com
OceanSaver Mark II	yes	final	yes	www.oceansaver.com
OptiMarin (OBS)	no	n/a	yes	www.optimarin.com
Panasia (GloEn-Patrol)	yes	final	yes	www.pan-asia.co.kr
Peraclean Ocean (Sky-System)	yes	basic	no	
RBT	yes	final	yes	www.resource-technology.com
RWO (CleanBallast)	yes	final	yes	www.rwo.de
Samsung HI (Neo-Purimar)	yes	final	no	
Severn Trent de Nora (BalPure)	yes	final	yes	www.severntrentservices.com
Siemens (SiCURE)	yes	final	no	www.water.siemens.com
BalClor (formerly Sunrui BWMS)	yes	final	yes	www.sunrui.net
STX HI (Smart Ballast)	yes	final	no	www.stxhi.co.kr
Techcross (Electro-Cleen System)	yes	final	yes	www.techcross.com
Techwin Eco (Purimar)	yes	final	yes	www.digitalvessel.com
Wärtsilä/Trojan Technologies Aquafine (TrojanUVLogic)	no	n/a	no	www.trojanuv.com
Wuxi Brightsky Electronic (BSKY)	no	n/a	yes	www.bsky.cn
21st Century (ARA Ballast, formerly Blue Ocean Guardian BWMS)	yes	final	yes	www.21csb.com/ www.samkunok.com

Notes:
Type approval status is based on information published by IMO in October 2012 and manufacturers' announcements since that date. This list is not exhaustive.

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ClearBallast
Hitachi



> The ClearBallast ballast water purification system was developed jointly by Japanese industrial giants Hitachi Plant Technologies and Mitsubishi Heavy Industries. It uses coagulation technology to remove plankton and organisms, and magnetic separation equipment to remove algae.

The coagulation method differs from sterilisation techniques in that it does not use chlorine, UV rays or disinfectants, thus removing the possibility of secondary contamination by residual chlorine.

Seawater taken in is treated by adding a coagulant and magnetic powder in coagulation and flocculation tanks. Agitation of the water causes plankton, viruses and mud to coagulate into 1mm-wide magnetic flocs. These can then be collected with magnetic discs in a magnetic separator.

Treated water is filtered through a filter separator and injected into the ballast tanks. The coagulation of micro-organisms into small flocs enables the use of coarse filters, which is claimed to result in high-speed treatment.

The flexible design is suitable for a wide range of capacities and can be modelled to fit the space available. Mud accumulation is said to be greatly reduced, thereby prolonging the life of the coating of the ballast tank.

Guardian
Hyde Marine



> The Hyde Guardian uses a two-stage disinfection process to fully meet IMO discharge requirements.

The first stage of disinfection is carried out by a stacked-disc filter system, providing the added benefit of depth filtration to eliminate chain organisms and ensure strong sediment removal. The second-stage disinfection is carried out with a broad-spectrum medium-pressure UV reactor. This combination of physical disinfection processes ensures no change to the water quality and no required contact holding time for the disinfection to take effect.

During ballasting, the ballast water passes through the filter and UV system and then back to the main ballast pipeline. During deballasting, the filter is bypassed and only the UV treatment is used to render any remaining organisms harmless to the environment. The Hyde Guardian system is offered as both a modular and skid-based design. A control panel manages the functionality of each component, the critical system valves and the optional booster pump, as well as interfaces with the vessel's central automation system to provide remote control for all critical functions.

Hyde Marine has sold and installed systems to all types of vessel, with flow rates from 60m³/h to more than 5,000m³/h, proving that the Guardian is suitable for all services.

Type-approved models are available for ballast flow rates from 60m³/h to 6,000m³/h. Hyde Marine has also completed retrofits with no down-time to the vessel, proving the system is easy to install and does not require time in a shipyard to conduct a successful retrofit.

EcoBallast
Hyundai HI



> The EcoBallast system developed by Hyundai HI does not use or produce any kind of chemical and therefore causes no secondary environmental contamination.

The modular BWTS, which has undergone full-scale testing at 200m³/h,

comprises: a 50µm filter with automatic backflushing; one or more UV reactors that can accommodate higher flow rates more efficiently; a high-intensity, medium-pressure ultraviolet lamp; and a control and cleaning unit (flow meter and alarms).

The ultraviolet reactor was specially designed for the ballast water treatment application to maximise the efficiency of the system, says the company. It adds that the system's controls have been embedded in an integrated control and monitoring system (ICMS), so that one operator is required for both the BWTS and ICMS.

HiBallast
Hyundai HI



> **The HiBallast system from Hyundai HI** is described as producing a high concentration of the disinfectant sodium hypochlorite by feeding a portion of the ballast water into an electrolyser module. The disinfectant is directly injected into the ballast pipe during ballasting.

A neutralisation agent is injected into the deballasting pipe to remove any remaining oxidant from the hypochlorite concentration, which could possibly have an unwanted effect on the marine environment if discharged without neutralisation.

Filtration of 50µm elements improves the efficiency of the electrolysis unit and maintains stable performance for various seawater conditions, says the company. A side-effect of the electro-chemical production of chlorine is the generation of hydrogen. Because the gas is highly explosive, it needs to be properly vented.

The company explains that the system's controls are embedded in a integrated control and monitoring system (ICMS), so that one operator is required for both the BWTS and ICMS.

BallastAce
JFE Engineering



> **BallastAce from JFE Engineering of** Japan is a ballast water treatment system that uses filtration and chlorination.

During ballast water uptake, water is pumped into a filter where plankton of 50µm or larger are removed and, at a certain pressure, backwash is discharged. Water is oxidised to eliminate marine organisms using disinfecting agent TG Ballastcleaner (developed by the Toagosei Group) in a dosing unit.

The water is then rapidly mixed and agitated via a mixing plate before being passed into the ship's ballast tanks.

During the discharge of ballast water, pumps direct the water past another dosing unit containing the reducing agent TG Environmentalguard, which reduces residual chlorine before the water reaches the sea. JFE BallastAce had more than 260 orders in 2012.

MicroFade
Kuraray



> **In the MicroFade BWTS from Kuraray** micro-organisms are removed during the front-end process through high-precision filtration, says the company. Sufficient amounts are filtered out in the first stage to make it possible to effect a substantial reduction in the amount of active substances in the second-stage chemical treatment, during the post process.

While ballasting is taking place, seawater is drawn into the system and passed through a filtration unit. The unwanted organisms

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are removed by the filters and discharged overboard, as filtered seawater proceeds through the system.

Active substances are automatically injected into the filtered ballast water by a chemical infusion unit. The disinfected seawater, infused with the active substance, passes to the ballast water tank.

During the deballasting process the levels of residual chloride concentration are measured and neutralisers are added automatically as required. A neutralising agent is infused when the chlorine level is too high. The treated ballast water is then discharged overboard.

An energy-saving operation is achieved by means of Kuraray's special filters with low-pressure requirements, which enables the MicroFade system to use existing power generators and ballast pumps. The compact design of the system's primary components (filtration unit and chemical infusion unit) allows for space to be conserved.

As it requires neither precise temperature control nor a large tank, the system also helps reduce power consumption and conserve space. These savings derive from the use of solid chemical agents that can be stored at room temperature.

En-Ballast
Kwang San



> **The En-Ballast BWMS from Kwang** San, based in Busan, South Korea, combines three modules for filtration, electrolytic disinfection and neutralisation.

The filtration module consists of a 50µm filter element with an automatic backflushing function, removing the larger particles and organisms from the seawater. It is fully automatic in terms of its operation and cleaning without interrupting the filtration process. Backflushed water is returned into the sea in situ. This filter operates only during ballasting.

The removal of larger organisms and particles by filtration reduces the amount of sodium hypochlorite required for disinfection. The electrolysis module generates sodium hypochlorite directly from seawater without the addition of or mixing with other chemicals, before the water enters the ballast tanks.

This module comes in models with different capacities, ranging from the En-ballast-500, which has a rate of 500m³/h at a power of 35kW to the En-ballast-5000, which processes at 5,000m³/h at 260kW.

During the deballasting process, total residual oxidants in the water coming from the ballast tanks are neutralised by sodium thiosulphate, which is injected from the neutralisation module.

The system is compact, can be designed as a skid-type version and is straightforward to configure and install in a limited space, says the company.

Ocean Protection System - KP
Mahle



> **The Ocean Protection System (OPS) is** a modular product that makes use of filtration and ultraviolet.

The two-phase pre-treatment filtration system is described by the company as low-maintenance and configurable for different flow volumes from 50m³/h up to 2,000m³/h. It can be operated either as a compact, container-housed unit or can be adapted to suit the vessel's design and layout, making use of available space. The filtration stages have automatic self-cleaning.

In the first stage a 200µm filter mesh is

used. With no interruption of the flow, these filters are automatically cleaned using the Bernoulli-principle. By a short increase of flow and simultaneous increase of differential pressure, coarse sediments and organisms are successfully removed from the mesh.

The cleaned water is then redirected to the second stage of the filtration system. In this the smaller particles are removed using a 50µm filter element, which is self cleaning.

The ballast water passes to a UV radiation unit using low-pressure UV lamps. Here the DNA of any remaining organisms is destroyed. The UV light is in the 254-nanometre range. During deballasting the water passes through the UV-unit again. Filtration is bypassed.

BAWAC
Maritime Assembly Systems



> **German company Maritime Assembly** Systems follows the G8 process with its BAWAC system. Land-based testing took place in a testing station in Singapore. The prototype 500m³/h BAWAC uses seven fluid-cooled, metal steam UV lamps.

A helix structure around the lamps ensures the water remains in the UV treatment area for longer than in straight-pass systems and distributes the light evenly. It also provides vibration damping for the quartz components.

The seven lamps are composed of three components. First, there is the high-performance, long-life burner itself, which has low energy consumption. The burner is surrounded by quartz glass, which supplies it with cooling fluid. The rotating helix component distributes the light. It is driven by ballast water, providing indirect cooling of the burner and mechanical damping of the quartz glass body. Wiper blades in the helix are pressed against the quartz glass cylinder hydraulically as water passes through the BAWAC, cleaning the system.

MH Systems in-tank BWTS
MH Systems



> **San Diego, California-based MH** Systems uses a combination of two treatment systems, deoxygenation and carbonation.

An inert gas generator (IGG) is at the heart of the BWTS. The inert gas, which consists of 84% nitrogen, 12–14% CO_2 and about 2% oxygen, is bubbled through the ballast water via diffusers with downward-pointing nozzles placed at the bottom of the tank.

IGGs infuse the ballast water with inert gas bubbles until it attains a state of hypoxia, with a pH of nearly 5.5. The gas infusion is controlled by a remote, automated, control system of valves, which can permit the tanks to be treated sequentially or all at once. Sensors detect the amount of dissolved oxygen in the ballast water and the pH level of each tank, and relay the information to a central control station.

This inert gas has the ingredients necessary to combine the two treatments of hypoxia and carbonation at what is claims to be a very reasonable cost. Analysis has shown that given the flow rates and control time for hypoxia/carbonated conditions, the gas needs only a short contact time to be effective. Tanks are rendered gas free by sending ambient air through the diffuser system to prepare ballast water for discharge or to prepare tanks for the entrance of personnel.

MH Systems works with IGGs that are already installed or a new generator can be fitted. Training is minimal because the system essentially consists of an on/off switch, says the company.

In addition to treating the water, the

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sediment particles are treated. Sediment does not clog up the diffusers because of their positioning and design.

FineBallast
Mitsui Engineering/MOL/ MOL Marine Consulting



> **The system employs the synergistic** effect of chemical treatment by the oxidation power of the active ingredient ozone and physical treatment using a specially designed pipe placed in the ballast water pipelines.

The organisms are killed off only at the time the ballast water tanks are filled. The system extracts the required amount of ozone from the air. As the right amount is produced, MOL maintains there is no requirement for a chemical agent for ozone supply or storage.

Micro bubbles of ozone are injected into the system, which achieves high efficiency levels for absorption and contact against the plankton and bacteria. Harmful substances remaining in ballast water are extracted by activated charcoal, a process that has no impact on the environment.

The system was audited according to G8 guidelines. Certification involved a full-scale land-based test of the system carried out by Mitsui Engineering & Shipbuilding and other participating companies, together with an onboard test on the MOL-operated container vessel *MOL Express*.

The system acquired the final approval under G9 guidelines at the end of September 2010.

Special Pipe Hybrid - Ozone
Mitsui Engineering



> **The Special Pipe Hybrid system (Ozone** version) from the Japanese shipbuilder Mitsui Engineering is a two-stage system based on cavitation by high shear and ozonation.

In the ballasting phase, water is taken into the pre-treatment unit before passing to a unit that injects ozone, which has been generated on board, into the water.

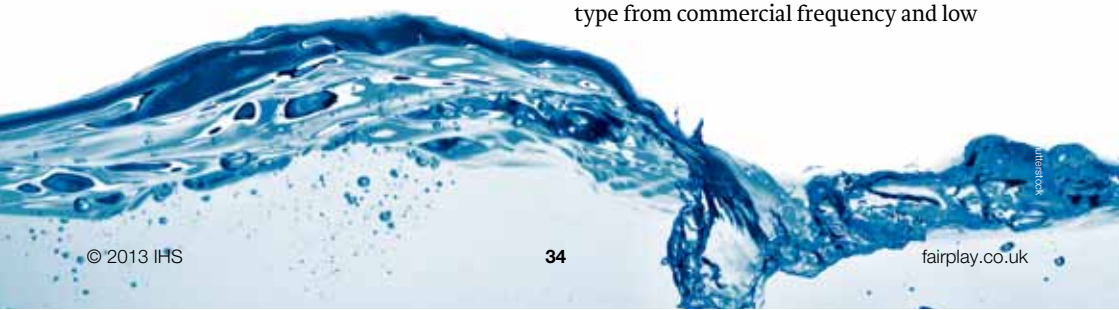
This method of treatment starts with inline pre-treatment to prevent blockage of the disinfecting unit, followed by a more complex mechanical treatment via a 'special pipe' that is inserted into a section of the normal ballast pipe run and then ends by adding the produced ozone, which is considered as an active substance by the IMO. After addition of the ozone to the water, for the treatment to be effective it is necessary for the ballast to be stored in the tank for at least 48 hours.

This minimum amount of storage time is needed to allow for the strong oxidising and disinfecting properties of bromate, which is generated from the reaction of ozone and seawater, to become ineffective.

The half-life of the bromate ion is, on average, about 12 hours.

A discharging unit decomposes the oxidant remaining in the ballast water at the time of discharge. The ozone generator contains multiple electrodes that convert part of the oxygen in the gas to ozone.

A power supply unit converts the power type from commercial frequency and low



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voltage to the medium frequency and high voltage most suitable to ozone generation.

A gas/liquid separation unit is employed to prevent ozone that does not react from flowing into the ballast tank.

VOS
NEI Treatment Systems



> **Venturi Oxygen Stripping (VOS) is a** physical process that removes dissolved oxygen (DO) from ballast water during intake only. This, the company claims, means no retreatment is required during discharge.

VOS does not require any filtration or active substance, which means the ballast pumps do not need to be changed.

According to the manufacturer, VOS uses a highly efficient stripping gas generator (SGG) to produce an ultra-low oxygen gas with only 0.1% oxygen. The gas produced is introduced to the ballast water via a venturi injector. This generates extreme cavitation, creating a micro-fine bubble emulsion in the ballast line.

Within about 10 seconds, more than 95% of the dissolved oxygen is stripped out of the solution and vented into the atmosphere.

Species dependent upon oxygen are suffocated, meaning many controlled organisms are dealt with within an hour, says the company, which adds that the oxygen levels are also high enough to prohibit anaerobic life. Many organisms are treated during the venturi phase of treatment itself.

Through the 95% reduction in DO, and maintaining a permanently inerted environment, oxidation of structure and coatings is virtually eliminated, says the company. The VOS treatment facilitates the complete removal of cathodic protection. NEI has six products, which range from 500m^3/h to 6,800m^3/h.

NEI's VOS process was the first BWTS in the world to receive type A approval, explains the company. It currently has approvals from five flags, which, combined, represent 45% of world tonnage.

NEI is a member of the US Coast Guard's STEP programme, and its system has been thoroughly reviewed by the US Environment Protection Agency.

BlueBallast
Nutech O3/NK Co



> **The BlueBallast system from Nutech** O3, based in Arlington, Virginia, in the United States, injects ozone into a ship's ballast water as it is taken on board. In seawater, the ozone will kill approximately half the invasive species on contact.

In addition, the ozone interacts with chemicals that naturally occur in seawater to create various bromine compounds that kill the remaining invasive species.

Ozone, as a gas, is not stored on the vessel but is made by taking ambient air and stripping out the nitrogen, cooling it, thereby concentrating the oxygen. It is then hit with a 10kV charge of electricity, which converts 10% of the concentrated oxygen into ozone.

The ozone is immediately injected into the ballast water intake pipe as the water is taken on board. Once it is injected into the ballast water, the ozone will revert to oxygen within just five seconds. Before it reverts, however, the ozone converts bromine, which occurs naturally in seawater, into hypobromous acid.

Trace quantities of bromine compounds, known as total residual oxidants (TRO), prove to regulatory authorities that the ballast water has been properly treated. Testing for TRO is a straightforward process

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that can be handled by most crew members.

To avoid any possibility of accidental damage, the oxygen storage tank is located in a protected space. As an extra safety precaution, the system's pipes are flushed with ambient air each time the system is shut down.

Mark I and II
OceanSaver



> **Norwegian supplier OceanSaver has** been able to position its second-generation BWT system in every target market, such as crude oil tankers, LNG carriers, chemical tankers and medium to large bulk carriers.

OceanSaver holds IMO D2 type approval from the Norwegian Maritime Directorate/ DNV and DNV type approval has been granted to OceanSaver Mark II.

OceanSaver's Mark II system disinfects filtered ballast water using the onboard generation of oxidants delivered to the ballast flow via side-stream injection from OceanSaver's C2E seawater activation unit. This unique technology provides a mixture of oxidants with rapid action and a very short half-life. When injected into the ballast water, these oxidants are able to eliminate the unwanted organisms. The process only requires a small dosage of oxidants compared with conventional electrolysis or oxidising disinfectants. The amount of total residual oxidant (TRO) is also greatly reduced within a few hours and neutralisation during de-ballasting is rarely required.

OceanSaver, together with DNV and coating suppliers, has carried out a successful 12-month coating and corrosion test.

During 2013 OceanSaver will have about 25 BWT systems in daily use on board VLCCs, Suezmax tankers, chemical tankers and medium-sized bulk carriers.

OBS
Optimarin



> **The Optimarin Ballast System (OBS) is** based on filtration as pre-treatment and high doses of ultraviolet irradiation for inactivation of marine organisms.

The system does not use nor generate chemicals or biocides in its treatment or cleaning processes. Ballast water is filtered only during ballasting but is UV-treated both during ballasting and deballasting to ensure the dual UV effect.

The system is normally installed as close as possible to the ballast pumps.

The modular system is flexible, with a relatively small footprint and weight, meaning it will fit vessels of different kinds and sizes.

The OBS can be delivered as a complete skid or customised solution. It accommodates a wide range of ballast water capacities and can handle flows up to 3,000m^3/h (or higher upon request).

The UV system consists of one or several UV chambers, each containing one lamp capable of a flow rate of 167m^3/h.

The chambers can be installed in parallel on a single manifold for higher flow rates and they are specifically developed and manufactured for installation aboard ships.

The system is self-cleaning, with no moving parts, so there is no need for chemical cleaning, according to the manufacturer. There is a UV and temperature sensor in each chamber.

Optimarin offers three 40µm filters: FilterSafe basket type; B&K candle type; and Filtrex basket type. All have automatic backflushing and are self-cleaning.

OBS also comes with an advanced UV control feature as an option that can be used to control specific elements of the UV system, says the company.

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This controller also makes it possible to store presets and specific configurations, such as how many UV chambers or pumps should be used. This enables the ship's crew to operate the system easily.

GloEn-Patrol
Panasia



> **A 100% physical treatment technology** has been adopted by Panasia of South Korea for its BWMS GloEn-Patrol, which eliminates harmful aquatic organisms and pathogens in water without generating any toxic substances during ballasting and deballasting.

The system combines filter and UV units, employs backflushing and is cleaned by automatic wiping. The filter unit maximises the disinfection effect of the UV unit by improving transmittance of UV light. The filter not only eliminates organisms larger than 50µm, but also minimises sediment in the ballast tanks.

Water enters through the inlet pipe into the filter area and flows through the cylindrical filter element from inside out. The filtration cake accumulating on the element surface causes a pressure differential to develop across the filter element. When this pressure difference reaches a pre-set value, or after a pre-determined time lapse, the backflushing mechanism kicks in. Backflushing takes 10–30 seconds. During the backflushing cycle the filtered water is not interrupted and continues to flow downstream of the filter.

Contaminated water is exposed to UV light. A real-time process control system activates and deactivates lamps to maintain the UV dosage while conserving power. This is controlled and monitored by means of a programmable logic controller (PLC) and touch screen.

Sky-System
Peraclean Ocean



> **The Sky-System ballast water** management system consists of treatment with the Peraclean Ocean preparation, which contains the active substances peracetic acid and hydrogen peroxide, which are stored in double-walled tanks.

The concentrations of the active substances are monitored and, if necessary, neutralised with sodium sulphite (Na_2SO_3) and water before the ballast water is discharged. The neutraliser is contained in epoxy-coated tanks.

Temperature and leakage sensors, temperature control unit, ventilators and sprinklers in the chemical storage room are used to prevent the temperature from exceeding 35°C.

During land-based tests using the concentration of active substance that is applied in actual operation, no corrosion was observed. Corrosive influences were reported to be acceptable on the ballast tank coatings and uncoated materials.

RBT



> **RBT's in-line ballast water treatment** system uses acoustic cavitation in-situ to produced disinfectants and physical separation by means of a self-cleaning 40µm filter to treat water on intake only.

The core of the treatment process is a set of reactors where sodium hypochlorite is produced through electrolysis. The sodium hypochlorite electrodes also provide the acoustic excitation for the cavitation process. Ozone gas is generated from ambient air and injected into the reactors.

These different treatment mechanisms have been shown to be individually effective, but also interact by means of sonochemistry,

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providing treatment efficacy at unusually low concentrations of the active substances, says the company. These low concentrations – 1ppm for each – mean predischarge neutralisation is not needed. Mixing in the reactors helps ensure that these unusually low levels of active substances come in adequate contact with target organisms, says the company.

A closed-loop control system is used to regulate sodium hypochlorite production and an open-loop control system regulates ozone production. The system has obtained IMO approval and testing will continue in 2013.

CleanBallast
RWO



> **The low energy consuming and robust** CleanBallast system is designed to be operated in-line using ballast water disk filters for particle removal and the advanced EctoSys electrochemical disinfection process during ballast water uptake.

For the first treatment step, Bremen-based RWO has designed a proprietary ballast water disc filter that achieves a high flow rate with a small footprint. The filters are designed to deliver excellent performance even during heavy-duty operation in harbours with high sediment load, where most ballasting operations take place. The second treatment step is RWO's EctoSys electrochemical disinfection system, which disinfects water from low to high salinity through highly effective and short-lived mixed oxidants.

While the ship is on a voyage, a regrowth of organisms in the ballast water tank is possible. Because the IMO standard has to be met at ship discharge, the ballast water is sent through the EctoSys process a second time during the deballasting phase, where bacteria and organisms regrown during the voyage, or already present in the tank, are eliminated.

In September 2012 CleanBallast underwent a slight modification. Based on the extremely positive operational experiences in the past, the design of the disk deep-filtration has been further optimised, enabling a smaller footprint. The tried and tested treatment principle thereby remained untouched. The optimisation has received official approval by Bundesamt für Seeschifffahrt und Hydrographie (BSH).

The CleanBallast system is also one of the very few systems that can demonstrate long operational duration in commercial application, as well as being upgradeable for even stricter future standards.

Neo-Purimar
Samsung HI



> **The Neo-Purimar system from** Samsung Heavy Industries treats ballast on uptake and discharge in a two-stage system. A 50µm self-cleaning filter removes particles, sediments and organisms during ballast uptake before being disinfected by electrolysis-based chlorination.

To minimise the use of the chlorine compound NaOCl, sodium hypochlorite solution generated from the electrolysis unit is injected to maintain a maximum chlorine concentration of 10mg/litre total residual oxidants. Water being deballasted is treated by additional disinfection – the sodium hypochlorite solution generated from the electrolysis unit is reinjected – and neutralised by a sodium thiosulfate solution.

Hydrogen gas, a by-product of the electrochemical process, is separated immediately upon exiting the electrolytic cell by cyclone separation and is not allowed to enter into the ballast water piping.

The gas is then transmitted to a de-gassing

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tank, which dilutes it to 1% (well below the 4% lower explosive limit) before exhausting to atmosphere.

BalPure
Severn Trent de Nora



> **BalPure, a treatment system based on** electrochlorination from US-headquartered Severn Trent De Nora, only treats ballast water during uptake, with no active treatment during de-ballasting.

Ballast water is first cleared of larger organisms and sediments by a 40µm filter. Once filtered, a slip stream of approximately 1% of the total ballast water uptake flow rate is fed to the BalPure system, where a hypochlorite disinfection solution is generated.

The mixture of seawater, disinfection solution and hydrogen gas (a by-product of the electrolytic process) then passes through a cyclone-type degas separator to remove the hydrogen gas. The 1% slip stream, now free of hydrogen, is mixed with the remaining 99% of the main uptake flow and used to disinfect the entire volume of ballast water. A residual disinfectant continues to treat the ballast water during the voyage.

The BalPure system is used in deballasting operations to neutralise the residual oxidant in the ballast water before discharge. Since no active treatment occurs on discharge, the power requirement for this process is negligible, measuring less than 2kW.

On deballasting, the filter is bypassed but before overboard discharge takes place an automatic neutralisation process occurs. A separate, small stream of a neutralisation agent, sodium bisulphite (7.5 litres/1,000m^3), is automatically added at the inlet of the ballast pump and any other discharge systems such as aft peak tank systems. Seawater, which is safe for the marine environment, is then discharged from the ship.

BalPure received IMO type approval in 2011. It also has approval from Bureau Veritas and is design assessed by ABS. Formal submission was made to the US Coast Guard in 2012 for the designation of BalPure as an alternate management system (AMS) as the first step to achieving full USCG type approval.

SiCURE
Siemens



> **The SiCURE Ballast Water** Management System, developed by Siemens uses a combination of filtration and a proprietary, on-demand treatment with biocides, produced in situ from seawater.

Based on the proven Chloropac technology, the system uses a small side stream to generate sodium hypochlorite for the treatment of ballast water. This offers several advantages, such as the flexible installation of small subsystems in the engine room.

The only component that is introduced in the ballast water main is the automatic backwash filter. This keeps the pressure drop over the system very low in comparison to in-line systems and avoids the need for explosion-proof design for the core parts such as electrolysers since they can be installed in the safe area of the engine room.

Another key advantage of the SiCURE system is its use not only in treating ballast water but also in treating cooling water circuits on board. Since ballasting occurs only during very short periods in a ship's lifetime, conventional ballast water systems remain idle for 95% of the time. By contrast, the SiCURE system can be used all the time, eliminating the need for an additional system to treat cooling water.

The system that received IMO final approval

in April 2012, is currently undergoing its shipboard testing. Under the surveillance of the German flag state administration, Bundesamt für Seeschifffahrt und Hydrographie (BSH), the system was successfully tested in both sea and freshwater onboard the 13,100teu container vessel *COSCO Fortune*, owned by Seaspan Corporation. Siemens expects type approval for the SiCURE system by mid-2013.

BalClor
Sunrui



> The BalClor BWMS from Sunrui treats ballast water by pre-filtration followed by disinfection using sodium hypochlorite solution (an active substance produced by an electrolytic process during ballasting) and neutralisation at deballasting using a sodium thiosulphate solution.

The water is filtered by an automatic backwashing filter with 50µm screen to remove most marine organisms.

For the initial disinfection stage, a small side stream of the filtered ballast water is delivered to an electrolytic unit in order to generate a high concentration of oxidants in a mainly sodium hypochlorite solution. Once this is done, the oxidants are injected back into the main ballast stream to provide effective disinfection.

As a very effective germicide, the sodium hypochlorite solution can be kept in the ballast water for a time to kill the plankton, spores, larvae and pathogens it contains.

For the neutralisation stage the total residual oxidant level of the treated ballast water is monitored and kept at 0.1ppm. If it remains above this level, the neutraliser solution, sodium thiosulphate, is added automatically into the ballast pipe at the deballasting stage to counteract residual oxidants instantly. If the residual oxidant level is below this level, the treated ballast water is discharged directly.

Smart Ballast
STX Heavy Industries



> Smart Ballast is an electrolysis-based BWMS developed by STX Heavy Industries. It is a one-step treatment system that sterilises for disinfection and does not use a filter. The active substances, created by an electrolysis activator, do not create any problems since they are completely neutralised by a counteragent during de-ballasting, says the company.

The automated neutralising machine is efficient and can save time, the company says, because the system produces a large amount of neutralisation fluid in a short period of time. It also has low operation costs due to low power consumption.

All system facilities can be operate manually, which makes the system easy to repair and maintain, says STX. The company also offers BWMS consulting and its system can be installed on new vessels and retrofits.

Electro-Cleen
Techcross



> The Electro-Cleen System (ECS) from Techcross employs electrolysis within the ballast pipeline to cause an active substance, sodium hypochlorite, and hydroxyl radicals to break down cell membranes and disinfect the ballast water.

The hypochlorite solution is a strong, sustainable disinfectant that destroys the cell nucleus, while the radicals are active only for nanoseconds.

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Seawater passes through an electro-chamber unit (ECU) placed after the ballast pump, and the disinfectants generated by electrolysis process are used to treat the harmful micro-organisms.

The company maintains ECS is the most effective BWTS using electrolysis technology.

Various models of the ECS are supplied: ECS-150B, ECS-300B, ECS-450B, ECS-600B and ECS-1000B. Explosion-proof versions are available, which are denoted by an 'Ex' prefix, for example, Ex-ECS-150B.

The system differs from a typical electro chlorination system, in that the treatment process provides electrochemical generation of the biocide solution on board and a high concentration of the hypochlorite solution is injected directly into the ballast pipe line.

When using electrolysis, the ECS applies electric currents. In the direct disinfection mechanism the electrical potential creates holes in cell walls, causing them to expand and break, thereby destroying the membranes of micro-organisms. In addition, the OH-radical generated during the electrolysis procedure by titanium electrodes acts as a disinfectant.

Through electrolysis, sufficient quantities of total residual oxidants are generated, preventing the regrowth of micro-organisms and maintaining the efficacy of the process. Residual chlorine also prohibits the regrowth of the organisms in the ballast tank.

Purimar Techwin Eco



> **The Purimar system is described by its** manufacturer as an efficient method of seawater electrolysis for safely generating sodium hypochlorite on board.

At ballasting, the ballast water treatment process performed by the Purimar system comprises the operation of two main units: filtration and disinfection. At deballasting, a neutralisation unit decreases the concentration of total residual oxidants before discharge if required.

The BWMS immediately injects the solution directly into the ballast water intake. The Purimar system involves passing a small supply (less than 1% of total ballast flow) of seawater from the incoming ballast water line through bipolar electrolytic cells in which it is subjected to low amperage and medium-voltage direct current.

The company says the system has a small footprint, is easy to install, and has low maintenance costs, with no increase to corrosion. Power consumption is predicted to be 26kW for a 600m³/h unit and 224kW for a 6,500m³/h unit.

Purimar was granted type approval on 31 October 2011 by the Korean Ministry of Land, Transport and Maritime Affairs.

Wärtsilä Marinex Wärtsilä/Trojan Technologies



> **Wärtsilä and Trojan Technologies** formally launched their Marinex system in October 2010.

The Wärtsilä Marinex ballast water management system performs its treatment in a two-step process, first by filtering out larger organisms and particles, and then by ultraviolet disinfection. The UV irradiation either kills the remaining organisms or renders them incapable of reproduction. Each unit is capable of treating 500m³/h and it is possible to install several units in parallel to produce higher flow rates, says the company.

The system's filtration unit and ultraviolet lamps that provide disinfection are housed

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in a single 2m³ unit. The system has a compact design, making it easy to install and it is suitable for most vessels. It offers low maintenance costs and high throughput.

BSKY
Wuxi Brightsky Electronic



> The BSKY system from Wuxi Brightsky Electronic of Jiangsu province, China, is modular in structure and uses what it calls Enhanced Physical Treatment, which is a BWTS that employs cyclonic and ultrasonic pre-filtration combined with UV irradiation.

On ballast intake, water passes through a hydrocyclone. This pre-filter has a strong separating performance, says the company, making the filter maintenance-free. This avoids clogging and there is no need to replace the filter. The ultrasonic pre-filter also limits the intake of organisms and sediment. The water is treated by a UV module, which destroys the micro-organisms.

During the discharge process, the water is treated again so as to eliminate any growth that may have occurred in the ballast tanks.

At this stage the hydrocyclone is bypassed.

The company argues that conventional filtration systems – those using a 50µm filter – can experience problems with clogging and often require replacement.

The ultrasonic pre-filter prevents regrowth and leads to lower power consumption on ultraviolet treatment. The modular design concept of BSKY BWMS means that it is flexible for engine room and pump room installation.

ARA Ballast (Blue Ocean Guardian) 21st Century



> This system is formerly known as the Blue Ocean Guardian (BOG) system. During ballasting, the filtration module of the ARA Plasma BWTS removes aquatic organisms and particles larger than 50µm. Backflushing water, which includes micro-organisms and particles retained by automatic backflushing devices, is returned overboard. After filtration, aquatic organisms are destroyed by intensive shockwaves produced by a low-voltage plasma module.

In the next step, residual organisms and bacteria are disinfected by a medium-pressure ultraviolet (MPUV) module. The MPUV module uses a wavelength of UV-C (200–280nm) to generate UV rays from a mercury-arc lamp. It is available for automatic cleaning in order to increase the penetration rate of a quartz tube.

During deballasting, while the filtration module is bypassed, the plasma module and MPUV module disinfect the water again to protect against micro-organisms and bacteria regrowth having occurred during the voyage.

Power consumption during treating water at a rate of 150m³/h was estimated to be less than 4.5kW for filtration, 13kW for the MPUV module and less than 1.5kW for the plasma module.

The ARA Plasma ballast system is said to be fully automatic and eco-friendly, with no chemical substances added for disinfection of ballast water. It is a compact system that offers convenient installation and a low power consumption. The sterilisation of ballast water is highly effective regardless of low salinity or high turbidity. ■



Shutterstock

BWTS kill species, such as plankton, that are picked up locally during ballast uptake

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What to consider

> Your choice of supplier needs careful consideration as the system is likely to be in use throughout the working life of the ship. Here are some questions you may want to ask when making that choice.

System supplier

- Is the supplier an established organisation that can demonstrate marine water treatment experience?
- Is it likely that long-term maintenance contracts will be honoured?
- Will spare parts still be available if the manufacturer ceases trading?

System status

- Does the system make use of an active substance?
- If so, has the substance been approved?
- Is the system type-approved?
- Can the manufacturer supply from stock or only to special order?

Active substances

- Is the active substance an additive?
- If so, is it readily available?
- Does it present any health risk to crew?
- Is there a risk that the active substance will affect ballast tank coatings? (For this to be established it may be necessary to discuss the matter with the coating manufacturer or require tests to be carried out.)

Cost considerations

- What will be the capital outlay per vessel?
- How much will the system cost to install?
- How long will it take to install?
- Is a fleet discount available?
- What are the system's running costs?
- What is the electrical power consumption of the system (minimum/maximum)?
- Replacement/additional filters/pumps?
- Maintenance and spare parts costs?
- Level of cost savings from less sediment and reduced damage to tank coatings?

Layout considerations

- How much space is available for installation?
- What are the installed system's dimensions?
- Piping and cabling requirements?
- Is it a modular system?
- Can the system be installed either vertically or horizontally?
- Space needed to store active substances?

System suitability

- Is the system designed and tested for prevailing realistic harbour conditions?
- Can the treatment process speed match the vessel's ballasting requirements?
- For scalable systems, how many will be required to match vessel requirements?
- If an active substance is used, will it be affected by salinity or temperature at ports in the vessel's normal area of operation?
- For vessels whose trading pattern involves short voyages, will the treatment process be completed in time for the next port call?
- If a retrofit, are existing pumps sufficient?

Operation and maintenance

- What level of training is needed by the crew?
- Is the system fully automatic or is crew intervention required during operation?
- Where substances must be added, is the dosing system fail-safe?
- How frequently do lamps or filters need to be changed?
- If a UV system, does the lamps' warm-up time affect the ship's ballast regime?
- What percentage of lamps must be operational for the system to be effective?
- Can off-the-shelf parts be used?

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Retrofitting systems

> Six more ballast water treatment systems (BWTS) have received type approval from their respective administrations since this guide was last published, bringing the total to 29. With so many systems now available on the market, shipowners have the opportunity to evaluate how they perform before the Ballast Water Management Convention eventually comes into force.

However, a treatment system that is optimal for one vessel, or a particular trade, may not be the best solution for another, and companies that provide support services to retrofit BWTS, such as Harris Pye Engineering in the UK, recommend that owners develop a shortlist of viable treatment systems that suit vessels' specific requirements and trade patterns, and then identify the initial expenditure required and operational costs involved in each.

The company says it is also important to evaluate the impact of integrating new a BWTS with existing systems, including demands on power, the possible effect of back pressure on pump and pipe capacities, and remote control and monitoring systems. The next step is to identify potential locations for the components from vessels plans and carry out an initial study on the installation costs involved with each system, including options for pipework.

As Harris Pye and other companies providing similar services, such as Marine Environmental Solutions, Elomatic Consulting & Engineering and Goltens, note, a 3-D laser scanning survey can facilitate these processes greatly and reduce the duration of the survey.

Goltens says owners thinking of retrofitting a BWTS need to be aware of some myths. The first is that it only takes a couple of months to install a treatment system. In fact, says Goltens, at least nine months of preparation are needed to deliver the system and get it class-approved. Another is that a vessel always needs to be in drydock for a system retrofit. Not so, says Goltens: in some cases it can be installed during normal operations.

Do your research

Christian Robeson, who is in charge of ballast water systems for classification society Bureau Veritas, said his best guidance for shipowners was to investigate carefully, take advice from a range of sources, and then evaluate that advice "with a lot of care and a degree of scepticism".

Robeson said owners also needed to bear in mind that for every ship and route the answer to the question 'what kind of ballast water treatment system should I fit' may be different. "Bureau Veritas has issued written guidance to owners on issues to consider, and has type-approved four systems using different technology," he said, noting that as well as the systems already approved globally, about 40 more were undergoing the approval process.

"We want to give owners balanced advice and not offer a seemingly simple solution to what is a complex situation," he continued. "You can opt for mechanical systems such as cyclones, filtration and flocculation, or physical systems such as ultrasound, ultraviolet or de-oxygenation, or there are chemical systems or biocides, electrolytic treatment or ozone. Each method has its advantages and disadvantages and so far, without large numbers of systems in service, it is difficult to anticipate which will emerge as the leaders for different types of vessel."

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He explained that while the type-approved systems had been bench-tested and then run for six months on vessels, the standards only require quite low flow levels to be demonstrated and do not guarantee that a system will work in all waters or situations. "What works for one ship might not work for another with different needs," he said. "No-one knows yet what will work best for 2,000m³/hour of very cold, very dirty, brackish ballast."

Peter Catchpole, a principle environmental specialist at Lloyd's Register, explained to IHS Maritime that some BWTS, such as electro-chlorination, result in the production of hydrogen, which needs to be managed by means such as by venting. This, too, needs to be taken into account when preparations are being made for a system to be installed.

Figure out the footprint

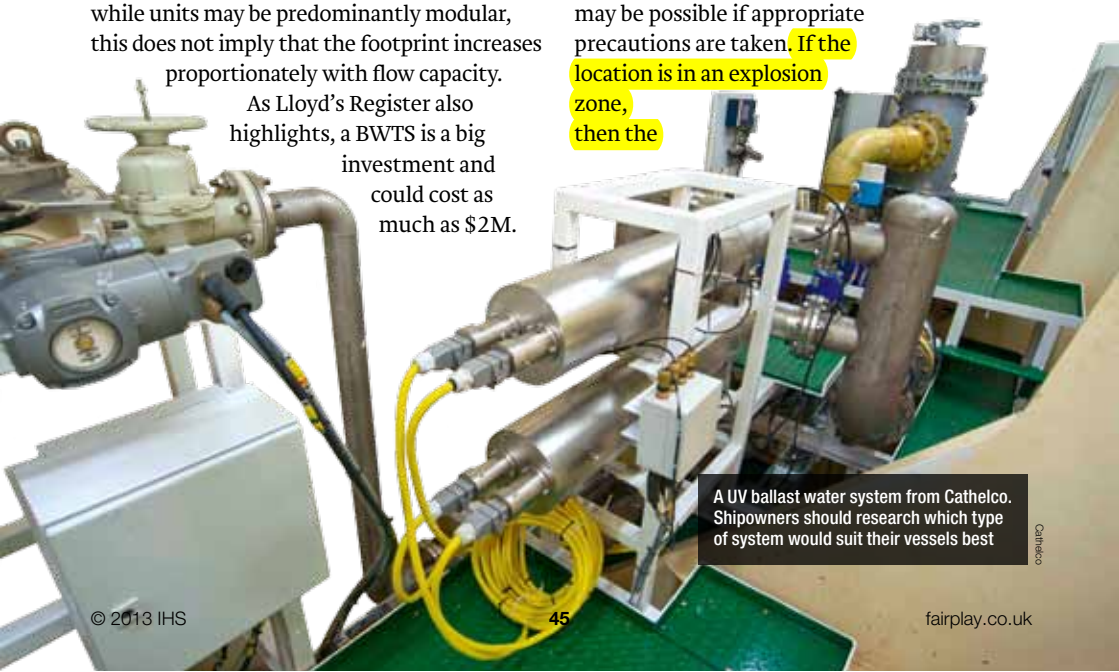
According to Lloyd's Register, the footprint of the systems, as reported by manufacturers, varies between 0.25m² and 30m² for a 200 m³/hr unit. As the classification society notes, while units may be predominantly modular, this does not imply that the footprint increases proportionately with flow capacity.

As Lloyd's Register also highlights, a BWTS is a big investment and could cost as much as $2M.

Operating costs depend on the type of system. Some have very high power requirements – as much as 220kW/1,000m³ of treated water – so it is important to check whether your vessel will need to run another generator when the system is in operation or even install an additional generator set.

Another consideration is whether you have a spare breaker available in the electrical distribution board to provide power to the treatment system. It is also advantageous to integrate the alarms and controls for the system with those for the ballast pumping system, so both can be operated from all control panels.

Dave Smith, general manager at Plymouth Marine Laboratory in the UK, told IHS Maritime he feared the cost of fitting a BWTS could drive some vessels, and owners, out of business, particularly those involved in shortsea trades, where margins are already tight. For most systems it is recommended that installation takes place in the engine/machine room, near the existing ballast water pumps, although installation on deck may be possible if appropriate precautions are taken. If the location is in an explosion zone, then the



A UV ballast water system from Cathelco. Shipowners should research which type of system would suit their vessels best

Cathelco

installation will need explosion-proofing. A number of suppliers, but not all, have type approval for explosion-proof systems.

The biggest operating cost for most systems is power, and for large power consumers – those BWMS that use electrolytic and advanced oxidation processes – availability of shipboard power will be a factor, said Lloyd's Register. For chemical dosing systems, required power is low and chemical costs are the major factor.

Essential planning

Jad Mouawad, head of the environmental protection section at classification society DNV, said good planning was essential. "From our experience I think it really pays for an owner to have someone at the yard during the installation and to make sure that crew are introduced to the operation of the system at the earliest opportunity so they can familiarise themselves with it before it enters service."

Julian Mason, a project director at Houlder Marine Design Consultancy in the UK, believes offshore and certain other small vessels could be more difficult to refit. "The Ballast Water Management Convention is putting operators under pressure to install [a]ballast water treatment plant on all vessels trading across international waters," he said. "The need to install [a] bulky treatment plant in already overcrowded machinery spaces could drive up the size of vessels."

Of course, one way to eliminate the need to treat ballast water is to remove it. With this in mind, Houlder has developed a 'zero-ballast' hullform. Mason said that, because of its reduced displacement at light draughts, this hull requires less power and therefore burns less fuel than an equivalent hull using fuller lines to accommodate water ballast. ■

> Remotely-sensed data aids ballast exchange

Most of the focus on ballast water treatment systems has been on selecting the right equipment, but Dave Smith and colleagues at Plymouth Marine Laboratory (PML) believe ballast water exchange and treatment could be significantly enhanced if vessels received data about where best to undertake the process. He notes that the level of plankton and sediment in the oceans varies enormously, so it makes sense to exchange ballast and flush tanks in the best possible location, route and schedule allowing.

PML believes a lot of the available systems are "on the edge of" working in a viable way. Smith said: "They could easily become overloaded with sediment or phytoplankton." He suggests that vessels integrate remotely-sensed data from satellites into their passage plans because the use of satellite technology makes it possible to locate, map and even identify individual species of plankton. "We are looking at how that kind of information might be made use of on the bridge of a vessel," he explained, using the weather routeing information already provided to vessels as an analogy.

Ballast water exchange has some operational shortcomings that technology doesn't really address, said Smith, primarily in terms of the biological and environmental conditions where the exchange takes place. "Discharging water loaded in port and then flushing your tanks in an area of high plankton concentrations doesn't make sense," he said. "Remotely-sensed data that is already available from earth observation satellites could be used to dramatically enhance the process and reduce the demands made on technology fitted on board vessels."

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Maintenance management

> It is hard to tell just how much a maintenance a ballast water management treatment system will require. DNV's head of environmental protection, Jad Mouawad, said: "At the moment we only have manufacturers' statements to go by. There is very little in-service experience with ballast water treatment systems on which to form any judgement about how maintenance-intensive they may be.

"Experience has shown that any marine system with a filter in it is likely to need a certain amount of servicing to keep it clean and functioning properly." A lot of filters are said to be self-cleaning but questions have been raised about filters' ability to cope with heavy sediment loads, which could lead to a reduction in flow rate. "Components such as UV lamps will need looking at every six months or so too, but the frequency of maintenance required will only really become clear later," said Mouawad.

Lloyd's Register's principle environmental specialist, Peter Catchpole, agrees that filters will need careful attention. "Filters remove organisms of a certain size but they are also designed to filter out sediment before treatment takes place. It will be important to keep them in good working order or else the effectiveness of treatments such as UV, which take place after filtration, could be affected.

"I think the most important point about maintenance is that you need to know back-up will be available if you need it. There are a lot of new systems out there. Many are from established manufacturers that will be able to provide in-service support wherever a vessel is, but this may not always be the case," he said.



A Brightsky Electronics BWMS is installed on a German vessel

Brightsky Electronic Co

Steer clear of fines

"It is important to be able to keep a treatment system operational. If it stops working, you will be in contravention of the ballast water convention and could face fines or detention, so owners need to check that spares, consumables and servicing are readily available wherever a ship is trading." Availability of components not usually found on a vessel, such as UV lamps and certain chemicals, also needs to be considered.

Other important consideration is the risk of corrosion caused by electrolysis, ozonation or chemical injection. The effect on ballast tank coatings of some of the processes and chemicals used in some treatment systems is still being researched although, as Lloyd's Register points out, it's widely agreed that purely mechanical treatment systems, which do not employ active substances, have no detrimental effect on epoxy ballast tank coatings. Research is continuing on the effect of 'active substances'. Some, but not all, manufacturers can provide reports on the effect of their systems on coatings. Those that use de-oxygenation bring with them the need to maintain the inert gas system used in the de-oxygenation process. ■

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RWO's CleanBallast – a sustainable system

> As one of the first ballast water treatment systems (BWTS) to be offered to the shipping industry, RWO's CleanBallast has proved itself on operating vessels and is now receiving repeat orders, the company explains.

CleanBallast was approved by German authority BSH in 2010. RWO considers it to be a future-proof solution for the treatment of ballast water as it accords with international regulations, is robust in design and has a proven sediment filtration system that helps minimise tank cleaning costs.

At the end of 2012 more than 90 RWO CleanBallast systems had been ordered, with more than 50% already in commission. Some owners have placed repeat orders, citing good operational performance and ease of maintenance.



The EctoSys module disinfects the water

RWO

Recent developments

As the first German manufacturer of BWTS, RWO received product design assessment (PDA) certification from Germanischer Lloyd for CleanBallast. Applications for US Coast Guard, and for its alternative management system (AMS), approval were submitted in mid-2012, and RWO is confident it will receive the AMS certification in the very near future.

The CleanBallast system has received a repeat order from a German shipowner that has been operating it on newbuildings transiting global trade routes. That owner has now decided to equip its entire fleet with

> CleanBallast – at a glance

- Disc filtration for efficient removal of sediments
- Electrochemical disinfection
- BSH-approved since 2010 and AMS approval anticipated
- Modular and robust in design to suit a variety of installations

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the CleanBallast system. It is one BWTS that can demonstrate long periods in commercial operation and RWO believes this demonstrates that it can withstand the uncertainties of the future.

The treatment principle of CleanBallast has remained unchanged since it was launched, with only the filter configuration and capacities adjusted following experience gained from use during commercial operation. These changes have led to a reduction in the system's footprint and it received official approval from BSH in mid-2012.



RWO

The effective CleanBallast filter system lowers tank cleaning costs

How it works

CleanBallast is modular in design and so is suitable for any type of installation. It is a two-stage process that uses in-depth disc-filtration combined with in-line electrochemical disinfection.

The system begins its work at uptake when raw ballast water is pumped evenly into the parallel-working DiskFilters. Each DiskFilter is equipped with a series of thin plastic filter discs, which are stacked on several spines. The hydraulic and spring-supported forces press the grooved discs together. When water passes through the discs, particles, fibres, algae and other organisms are retained on the outside surface of the discs and in the grooves.

When a predefined differential pressure is reached, the fully automatic backflushing mode starts. The spring that compresses the discs in the filtration phase is automatically released by the pressure of the flushing water (treated ballast water) and thereby eases the compression of the filter discs. Flushing water then flows from the cores of the elements to the peripheral ends of the filter discs and sets them into rotation, which backwashes the filter in a few seconds. The DiskFilters also act as a pre-treatment, which considerably lowers tank cleaning costs and prevents the loss of valuable load capacities.

The second stage involves EctoSys disinfection technology, which has been created to work in both sea and low-salinity water, to disinfect the ballast water in an economical, ecological and operator-friendly way.

Electricity is applied to the water and disinfectants, as a result of this process, are created in the water while it passes through the piping. Because of the chemical and electrochemical properties of the electrodes used, they produce – among other disinfectants – very short-living and reactive hydroxyl (OH) radicals, which eliminate bacteria and organisms.

EctoSys has been designed to work in waters with a very high or low salt content, as it produces a different active substance depending on the salinity of the water. In water with low salinity it only produces hydroxyl radicals but, if treating brackish or seawater, it produces short-living hydroxyl radicals, chlorine and bromine. The residual disinfectants – chlorine and bromine – can be analysed as total residual oxidant (TRO). ■

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About RWO Marine Water Technologies

> Bremen-based RWO is one of the leading suppliers of water and wastewater treatment systems on board ships and offshore installations. For more than 35 years RWO's experts have been developing, designing, manufacturing and servicing forward-looking and cost-efficient technologies for any kind of water treatment. Whether ballast water treatment, oil/water separation, waste water treatment, process water treatment or freshwater treatment for newbuildings or retrofitting, RWO has a solution.

RWO's network of more than 40 qualified sales and service stations established throughout the world aims to provide its customers with short communication links and rapid response times. ■

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Printed by Warners Midlands plc, The Maltings, Manor Lane, Bourne, Lincolnshire

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