Ballast water management strategies for tanker operators

The transfer of invasive marine species into new environments via ballast water has been identified as one of the major threats to the world's oceans.*

In 1992 the United Nations Conference on Environment and Development (UNCED) called on the IMO to take action to address the problem. The IMO had been seeking a solution for over 10 years, publishing in 1991, 'Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ship's Ballast Waters and Sediment Discharges'.

In 2004, and only after a long series of international conferences, the IMO finally achieved the International Convention for the Control and Management of Ships Ballast Water and Sediments, known as the Ballast Water Management Convention (BWMC).

By January 2015, 44 countries owning 32.57% of the world's merchant fleet had ratified the convention, which only comes into effect 12 months after 30 countries, representing a combined total gross tonnage of more than 35% of the world's fleet, have ratified it. Commentators believe this will happen sometime this year or certainly by 2016.

According to the IMO, 3-5 bill tonnes of ballast water is transported annually around the world. The major characteristics of the tanker sector, certainly as far as ballast water is concerned, are the huge volumes of water involved, the criticality of the ballasting and deballasting processes to the smooth completion of terminal operations and the size and power of the BWMS required to handle the flow rates involved.

Most ballasting systems have a pump capacity that allows the total ballast to be emptied or filled in 10 - 20 hours. Any time lost to BWT through breakdowns or filtration blockages will result in considerable additional costs to the vessel operator.

Oil and chemical tankers, LNG/LPG carriers and larger bulk/ore carriers sailing halfway around the world are the types of vessel most likely to transport unwanted organisms in significant numbers inadvertently given the volumes these vessels carry. For example, a typical VLCC will be carrying around 100,000 cu m of ballast water, so addressing the specific operational requirements of these types of vessels is vital to the success of the IMO convention in dealing with alien nuisance species.

As the IMO convention comes into force, cumulative investments of over $30 bill into BWTS are expected over the next decade, according to a study by analysts Frost & Sullivan. More than 57,000 vessels will require a BWMS driving a massive boom in orders. Capital costs will range from $175,000 to $3 mill.

The emerging ballast water management market has attracted over 70 manufacturers bringing differing experience, expertise and background; some are traditional marine engineers, others have a history in water and wastewater management, some are shipbuilders, others are shipowning companies in their own right, but almost all BWMS on the market today rely on a combination of two out of three basic processes; mechanical filtration to remove larger organisms followed by either chemical treatment or physical disinfection to or render non viable smaller and micro-organisms

All BWMS, which involve filtration do so down to the 40 or 50 micron level, although there is one system that goes as small as 10 microns. All filters rely on automatic backwashing to maintain flow and discharge waste. For tankers, the intake rates can be as high as 6,000 - 8,000 cu m per hour and this is where the problems can start because reliably filtering such a volume of water can be challenging, especially in areas where ballast water may contain high levels of suspended solids. The pretreatment filtration causes pressure drop in the ballast circuit, the amount varies depending on pump pressure, design of the ballast head and location of the installation.

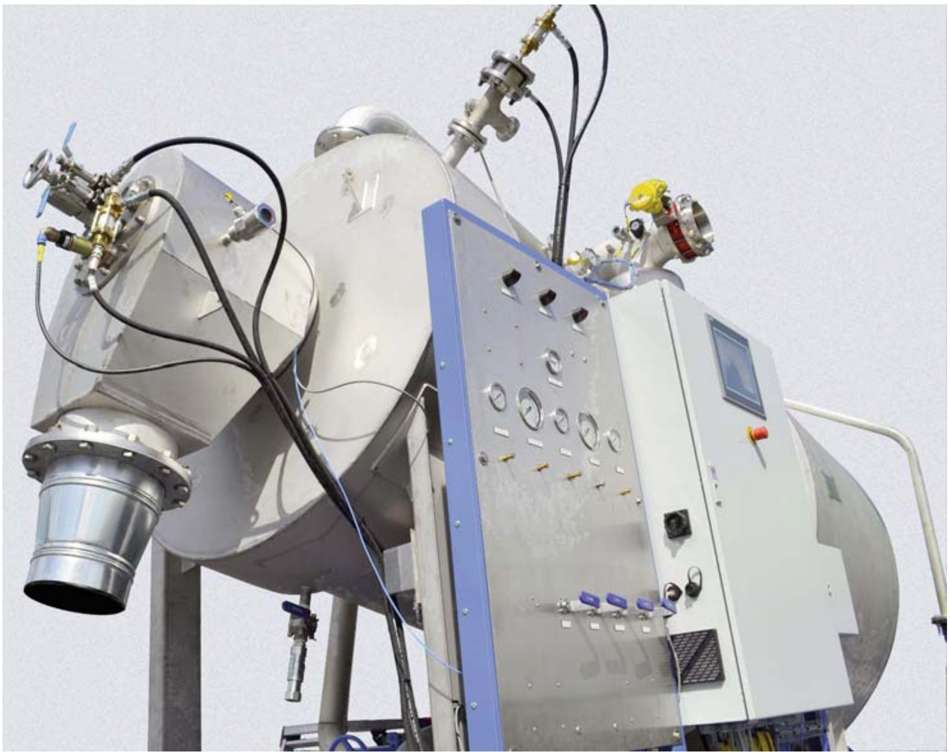
The second stage of treatment has to be large enough to manage the water flow at the same rate as it is pumped on board. One solution is to run two or more treatment systems in parallel but this needs space and often complex piping and manifold arrangements in areas where space is already at a premium.

BWMS based on UV technologies run water past a UV source that irradiates any organisms at wavelengths damaging to their DNA, rendering them non-viable. Should organisms need to be killed (such as is currently the case for US Coast Guard type approval), ballast water must be exposed to more powerful irradiation for longer resulting in an even greater space requirement, greater power demand and reduced UV source life. UV sources must be regularly cleaned and cannot be used in turbid water.

It is sometimes suggested that re-irradiating the ballast water prior to deballasting might be an answer to the problem of killing those organisms that have blossomed following re-growth in the ballast tanks during the voyage. But this approach is not universally accepted and effectively doubles the risk of BWMS interference in vessel terminal operations. Newer generations of UV BWMS are certainly more flexible and efficient than are the original designs, but there are still vessels whose the huge ballast capacities, high pumping rates, power availability and space availability make UV impractical.

Complicating matters, the USCG is currently drafting its own approval processes requiring that discharged ballast water contains no living organisms whereas the IMO regulations provide only for organisms to be non viable- unable to reproduce- when discharged. In the short term, the USCG has allowed Alternative Management System (AMS) status to systems already type approved by other regulatory bodies while it studies the effectiveness of UV treatments.

Tanker owners can opt for systems using chemically active re-agents like chlorine, chlorine dioxide, ozone, peracetic acid, hydrogen peroxide or sodium hypochlorite. Electro-chlorination (electrolysis) of salt water produces chlorine entities, which destroy cells but have the disadvantage that they cannot operate reliably with fresh water or at low temperature.



Coldharbour's marine inert gas generator.

While the power requirements for electrolysis systems are lower than that of UV systems, they can still be considerable and the issue is further complicated by the variations in power demand caused by changes in salinity, temperature and the combinations thereof. Water is treated during ballasting but, as with other in line system, the risk of organism re-growth in the ballast tanks over a long voyage is acute.

The concentrations of residual chlorine in ballast water drops below the 8 ppm needed to achieve a kill, within just a few days, and attempts to boost chlorine levels passed through to the tanks can result in significant (and costly) corrosion damage to tank coatings and thence vessel structure.

Electrolysing seawater also produces hydrogen and chlorine gases as by-products and it is clear that these systems must be handled with great care. At least four vessels relying on electro-chlorination BWMS have suffered on board explosions for reasons that are not clear in all cases. For these reasons, the use of chlorine in the ballast water of chemical or LNG/LPG carriers is thought to introduce unnecessary risks.

In 2015, Bawat unveiled a new BWMS that uses reclaimed waste heat energy from the ship's engines. Ballast water is heated to 72 deg C and then flows back into the tanks to allow pasteurisation to take place during voyage. Bawat reported good results on smaller vessels but as ballast volumes scale up, the on board energy/heat transfer demands struggle to scale proportionally.

Mechanical systems have the benefit of avoiding the use of active chemicals in contact with water or tank linings and so minimise corrosion risks. The most recently accredited BWMS is based on physical methods of killing micro-organisms, using de-oxygenation and ultrasonic cellular disruption.

Coldharbour Marine, decided to focus on the needs of tanker operators, calling upon the company's 35 plus years of experience of supplying marine inert gas systems (FGS + IGG) to these customers.

Instead of adopting a traditional (land type) water treatment technology, Coldharbour began with a clean sheet and undertook an in-depth study of the views and requirements of owners and operator contacts. These indicated that an optimal system would operate to treat the water during the voyage and in the ballast tank. This is because the demands made on personnel, managers and power systems in port were such that adding the pressure of managing BWT with the need to cope with high pumping rates and raised power demands at the same time was one distraction too many.

Coldharbour developed its design brief accordingly and designed and built a system that delivered just what tanker operators had requested - a system that guaranteed no disruption to port operations and guaranteed no risk of organism regrowth during long voyages (> 10 days).

Following successful bench tests, Coldharbour retrofitted its BWMS onto a VLCC for sea tests, being the first retrofit of such a tanker completed anywhere by any BWMS supplier.

Coldharbour's in tank, in voyage system uses three complementary mechanisms to achieve its BWMS. First there is no filtration step. Instead, ballast water is pumped into the tanks as normal and treatment is not started until sometime after the voyage begins. At this point, inert gas is pumped into gas lift diffusion (patented GLD) units mounted inside the ballast tanks. These GLD units stir the tanks using fluid dynamics. There are no moving parts and no electrical connections or pumps but the GLDs are remarkably efficient in their stirring action with each capable of moving 1,000 cu m of ballast around the tank each hour.

A typical VLCC installation would see five GLD units per main ballast tank and a smaller number for the forepeak and after peak tanks - making a total of about 55 GLD units on a VLCC, all easily installed in the vessel's ballast tanks.

The de-oxygenated inert gas containing <0.2% O_2 removes the dissolved oxygen in the ballast water replacing it with CO_2 and killing organisms by asphyxia. As the CO_2 dissolves, the water pH temporarily drops, becoming mildly acidic and killing anaerobic organisms by hypercapnia. Finally, as the inert gases are introduced into the ballast water through the GLDs, an ultrasonic shock wave is produced inside the GLD, which is tuned to disrupt the cell structures of any remaining micro-organisms such as E coli, Cholera and others.

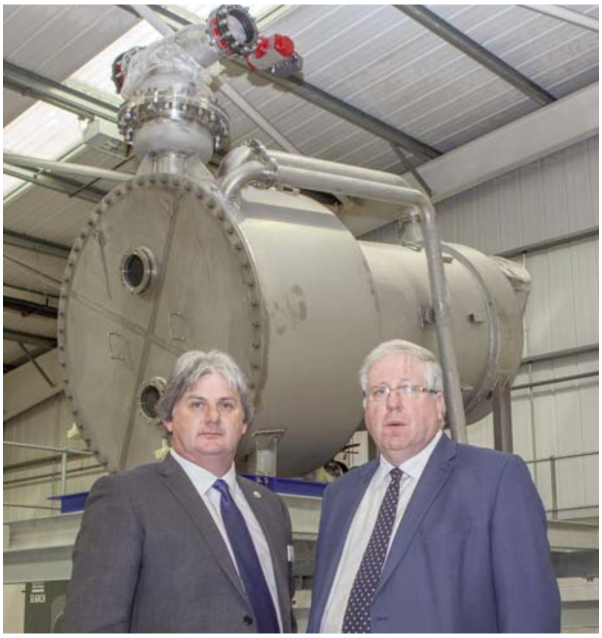
The water treatment requires just a few hours to complete and, by taking place during the voyage, pressure on crews is reduced and no additional power is required during critical time spent at terminals. With the water in the tanks full of inert gas, there is no risk of re-growth with this system.

The ballast water is re-oxygenated prior to discharge by passing air through the GLD units. This is mandatory, as it ensures that the water is at the correct pH for legal discharge. This approach is particularly effective for vessels with large ballast capacities, high ballast pumping rates that are critical to cargo operations and long ballast voyages where re-growth would be a major concern.

Corrosion and coatings impact research was undertaken by Coldharbour with Jotun and International Paints and these showed that the rate of tank corrosion experienced was significantly reduced - representing a useful additional cost saving. In 2015 the Coldharbour BWMS received IMO type approval from the UK MCA with all testing overseen independently by Lloyd's Register.

Andrew Marshall, Coldharbour Marine CEO, explained why a VLCC was chosen for sea trials, "We wanted to demonstrate our system on a real vessel under challenging conditions. In our tests, we studied the impact on organisms down to 2µm even though the target level stipulated was 10µm.

"After all, small organisms grow into large organisms given the right conditions. We decided long ago that it was not possible to



Coldharbour Marine CEO, Andrew Marshall, with the UK Secretary of state for Transport the Rt Hon Patrick McLoughlin seen in front of BWT equipment.

offer one system that would satisfy all vessel types and, having previously supplied Inert gas systems, it made sense for us to use our IGG system and develop the patented GLD units enabling us to offer a truly innovative, in tank, in voyage, BWMS to tanker operators," he said.

At the end of April, Coldharbour Marine's new headquarters was opened by the Rt Hon Patrick McLoughlin, UK Secretary of State for Transport.

Coldharbour is now based in a 25,000k sq ft building in Linby, Nottinghamshire. Previously spread over three sites, Coldharbour's administrative headquarters, design office, research laboratory, development and factory acceptance test (FAT) facility, rig, stores and warehouse, together with a high-tech assembly shop are now under one roof.

The investment was awarded as part of the Unlocking Investment for Growth (UI4G) programme, funded by the Government's Regional Growth Fund and the European Regional Development Fund. UI4G awards are given by the D2N2 Local Enterprise Partnership whose role is to promote economic growth and job creation in Derby, Derbyshire, Nottingham and Nottinghamshire.

Recruitment

The projected international demand for BWTS is underpinning an ambitious recruitment campaign, as the company is in the process of recruiting 100 full time staff, including marine engineers and designers, project managers and mechanical engineers.

According to Marshall, "The move to larger premises is part of a planned expansion of our inert gas business and will ensure that Coldharbour is able to satisfy shipowners and operators demand for products. We anticipate the imminent introduction of the IMO's ballast water management convention will trigger huge international demand for ballast water management systems worldwide."

**This article was written by Mark Wells, Chief Technical Officer, Coldharbour Marine.*