Expanding the Role of UV into Ballast Water Treatment

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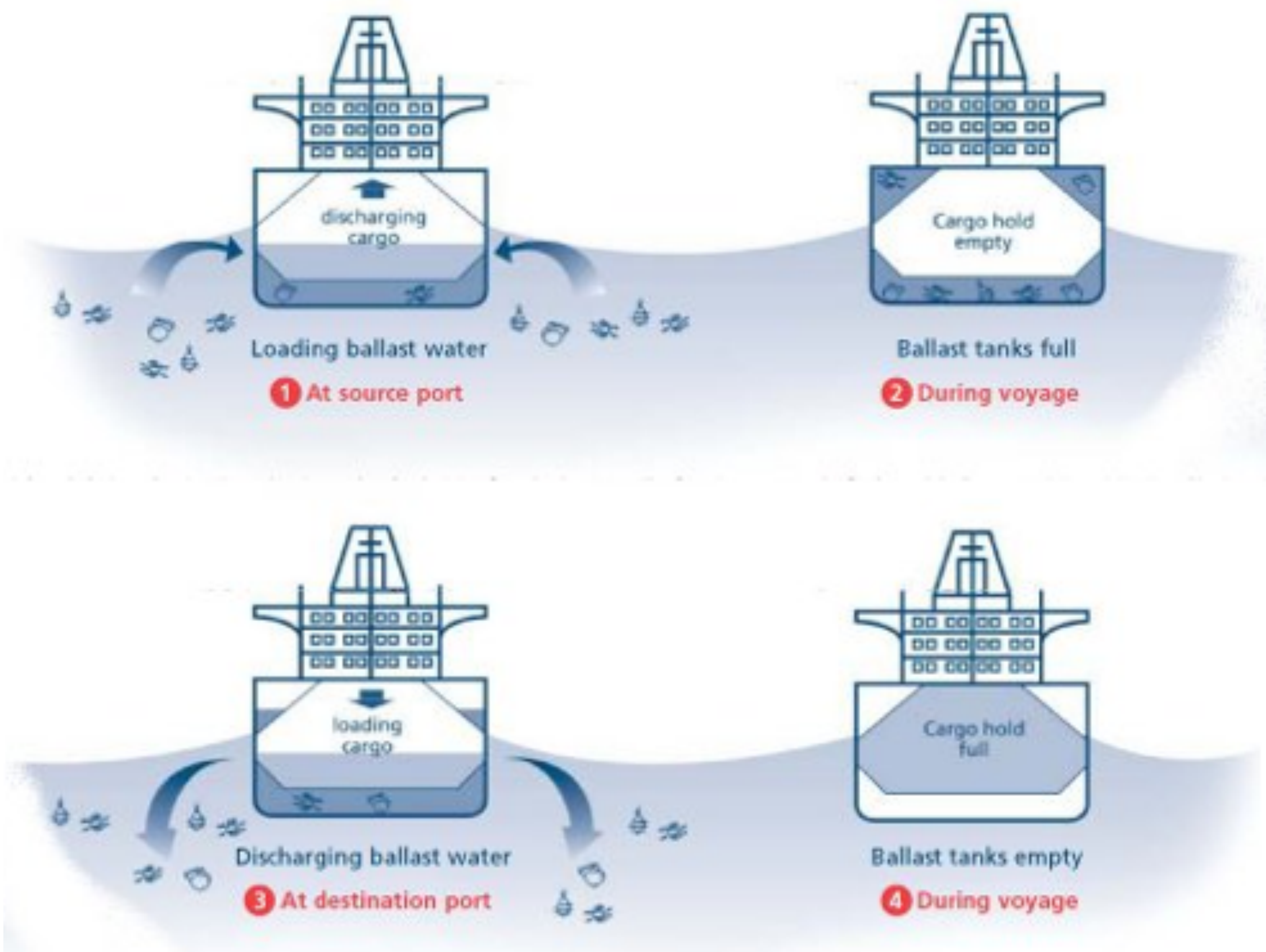
BALLAST WATER OVERVIEW

The maritime shipping industry moves over 90 percent of the world's freight and relies heavily on ballast water for safe vessel operation. Ballast water is pumped from the sea into tanks to adjust trim and to maintain the balance and stability of ships with varying amounts of cargo.

WHY TREAT BALLAST WATER?

As vessels move from port to port, they move billions of tons of ballast water around the world. In this water could be thousands of marine species ranging from bacteria and viruses to the eggs and larvae of larger vertebrate species. These species carry the risk of being invasive and damaging to the environment they are introduced to when ships offload ballast water. In the USA, the European zebra mussel is the prime example of an aquatic invasive species that was introduced via ships' ballast water. Zebra mussels attach to and clog the water inlets of municipal water supplies and the cooling water intakes and equipment of industrial plants. The cost of battling the zebra mussel invasion has been estimated at over $5 billion since their introduction.



HOW TO TREAT BALLAST WATER

In response to the threat of aquatic invasive species, several technologies have been developed into commercial ballast water treatment systems (BWTS) to disinfect ballast water used on ships. Systems have been designed for flow rates ranging from 50 – 10,000+ m3/hr (0.3 - 63+ Million Gallons per Day) and for operating pressures from 1 - 10 bar (14.5 - 150 psi). Typically, these systems rely on multi-stage processes consisting of a physical separation stage followed by at least one disinfection stage. The physical separation stage is typically handled by filtration to remove large sediment particles and zooplankton (organisms larger than 50 µm). Disinfection stages currently used rely on ultraviolet, chemical, electrolysis, de-oxygenation, or electro-chlorination technologies. Chemical disinfection is achieved using biocides which must be stored onboard the ship. These chemical inventories represent a safety risk to the crew and come with a significant space and cost requirements. Electro-chlorination systems create hypochlorite (and thus chlorine) from salt water, which has the potential to increase corrosion in ballast tanks and piping systems. The hydrogen created during the electro-chlorination process must be carefully managed and presents an explosion risk to the ship. Additionally, residual biocides and chlorine in the ballast water must be neutralized before being discharged to the environment. De-oxygenation systems are quite complex since they typically require multi-tank, inert gas blanketing and monitoring requirements. UV systems by contrast are simple and safe, turn them on and turn them off processes. For this reason, UV based treatment systems make up over 60 percent of the systems installed to date.

APPLICATION OF UV FOR BALLAST WATER TREATMENT

UV ballast water treatment has some unique characteristics when compared to other UV water disinfection applications. There is no single target organism because every species in ballast water could pose a threat. Additionally, there is no defined, typical port water composition. This makes it difficult to define a standard amount of UV radiation to apply to the water. From one ballasting operation to another, there could be two or three orders of magnitude difference in the number of organisms present. By regulation, ballast water treatment systems must achieve specific numerical organism discharge limits - not (as in drinking water treatment) to meet a particular percent reduction of organisms. Further complicating matters, the UV transmittance of port water (a measure of how easily UV can penetrate the water) can change moment to moment with something as simple as changing tidal direction creating significant variation in UV transmittance. As such, UV systems must be able to increase power output quickly to compensate. Finally, system flow rates can also change. Many ships have two more ballast pumps, which can be run in several combinations creating multiple operating flow rates and system pressures. For these reasons, large safety factors and accurate instrumentation must be designed into the treatment system to respond to the ever changing conditions.

Installation on ships is also vastly different than conventional land based UV installations. Ships are constantly moving and vibrating. Shipboard equipment must function when inclined and rolling over 20 degrees, must endure the constant vibration of the main engine and propulsion systems, and must operate in a wide temperature ranges of both the ambient conditions and the process fluid. Some ships also require the equipment to be installed in areas that have potentially explosive atmospheres, so the UV chamber must be designed to be explosion proof. Additionally, since ships operate in remote corners of the world with minimal crew, the systems must be robust enough to require minimal maintenance and care during their use and lifetime.

Recognizing both the challenges and opportunities in the ballast water treatment market, many UV disinfection manufacturers have entered the market either through discrete offerings or via partnerships with established marine equipment vendors. Both low pressure and medium pressure UV disinfection stages (refers to the type of lamps employed) have been shown to be effective during land based and shipboard type approval testing. UV system suppliers test their equipment in accordance with the IMO G8 testing protocols in order to establish the UV dose that their systems apply to the water. This dose is typically expressed as a minimum required dose with the UV reactor and process control equipment modulating either ballast water flow rate or lamp intensity or

both to insure that the applied dose meets or exceeds the dose measured during validation testing.

UV treatment manufacturers additionally rely heavily on the physical separation stage of their treatment system or some alternative disinfection stage for the large, multi-cell organisms that are more resistant to the DNA-damage inflicted by germicidal UV. These physical separation stages typically consist of a fine-mesh (20 – 50 micron) filter or a hydrocyclone. The large sediment loading that vessels often encounter when ballasting at a port location can create fouling concerns for these filters, however most modern ballast water treatment systems are fitted with advanced, self-cleaning filters capable of handling both high sediment and organic loading.

There has been some developmental research regarding the primary effects of UV-C and secondary effects of UV-B and UV-A radiation on marine microorganisms, but to date, full dose response curves have not been developed for the suite of marine microorganisms. As ballast water treatment manufacturers gain more experience and have working shipboard systems capable of being tested under the wide ranging conditions found across the world, the effectiveness of UV on the full suite of marine organisms will be reinforced. Ballast water treatment testing onboard working vessels is often complicated by non-standard interconnections of piping (e.g., grey water and ballast water) and the lack of sterility in shipboard piping and tanks. Given that ballast water treatment must often achieve 99.99 percent removal of organisms, even small contamination from ancillary systems can significantly impact test results.

INTERNATIONAL REGULATION

Recognizing the severe environmental and economic impact of aquatic invasive species transported by ballast water, the International Maritime Organization adopted the International Convention for the Control and Management of Ship's Ballast Water and Sediments. For the convention to come into force, 30 nations representing 35 percent of the world's shipping tonnage must sign it; to date, about 40 countries have signed, representing 30.25 percent of the world's tonnage. When the convention is finally ratified, the discharge regulations will be phased in over a number of years for different ships depending on ballast capacity. Existing ships without treatment systems will have to conduct retrofit installations and new construction vessels will have to have systems installed upon commissioning. That amounts to roughly 60,000 ships worldwide.

UNITED STATES REGULATION

The United States Coast Guard has taken its own approach to ballast water management regulations. In December of 2013, U.S. ballast water management regulations came into force that require ships that discharge ballast water in the U.S. to use a U.S. Coast Guard Type Approved treatment system. However, as of August 2014, there are no USCG Type Approved treatment systems. To bridge the gap, the USCG is issuing Alternative Management System certifications. This is a temporary certification, allowing ship operators to be compliant for up to five years until Type Approved systems become available.

Hyde GUARDIAN installed aboard a bulk cargo vessel. Shown is the filtration system, two UV chambers, and the controller. System capacity: 500 m3/hr.

THE UV TESTING CHALLENGE

One of the reasons for the lack of U.S. Type Approved systems is that the only U.S.- approved protocol for testing ballast water treatment systems relies on vital stains and fluorescence to enumerate the number of organisms discharged by ballast water treatment systems. Vital stain methods can work to determine the effectiveness of some disinfection technologies but not UV systems. UV disinfection works primarily by causing DNA damage in organisms to render them harmless. Vital stain test methods cannot measure this effect and are thus insufficient for testing UV systems. The USEPA established a technical panel to evaluate alternative testing methods for UV based BWTS. The panel is composed of UV manufacturers, Coast Guard, EPA, academic and private sector research communities, and BWTS testing facilities and is working towards validating a test method that accurately measures the effect of UV disinfection.

CONCLUSION

The transport of aquatic invasive species in ballast water poses a very tangible threat to both marine ecosystems and economies. Existing and pending regulations should mitigate that threat by mandating the use of ballast water treatment systems. Of the various treatment technologies available, ultraviolet based systems are the safest and simplest and are the preferred choice of vessel operators.

ABOUT HYDE MARINE

Hyde Marine, Inc. is a world leader in ballast water treatment systems designed to control the spread of non-indigenous aquatic organisms. Owners and operators committed to operating their vessels in a responsible, sustainable, and economical way rely on the Hyde GUARDIAN GoldTM Ballast Water Treatment System (BWTS) to provide an IMO type approved solution to maximize their ship's environmental compliance. The Hyde GUARDIAN Gold system is suitable for a broad range of treatment requirements based on our many years of experience and can be retrofitted in-situ to existing vessels with no downtime. Hyde Marine is a pioneer in early ballast water research and continues its position as a technology leader and an integral part of Calgon Carbon UV Technologies.

ABOUT CALGON CARBON CORPORATION

Pure Water. Clean Air. Better World.

Calgon Carbon Corporation (NYSE:CCC) is a global leader in innovative solutions, high quality products and reliable services designed to protect human health and the environment from harmful contaminants in water, and air. As a leading manufacturer of activated carbon, with broad capabilities in ultraviolet light disinfection, the company provides purification solutions for drinking water, wastewater, pollution abatement, and a variety of industrial and commercial manufacturing processes.