BALLAST WATER TREATMENT METHODS

Fact Sheet 10 — Chemical Biocides

Ozone

Purpose

Organic acids and a variety of disinfectants have been successfully used for years in the land-based treatment of potable water. Chemical treatment of ballast water involves the addition of a specified volume ("dose") of chemical to the tanks, thorough mixing, and the maintenance of a residual chemical level to ensure effectiveness. Effective chemical treatment of ballast water should result in elimination of a broad range of nonindigenous species (NIS), a quick decay rate, and degradation into non-toxic compounds prior to discharge. As discussed in the Technical Fact Sheet titled "*Chemical Biocides – Organic Acids and Other Disinfectants,*" other chemical treatment options include bromine, chlorine, chlorine dioxide, hydrogen peroxide, and other chemical alternatives. Ozone is a promising treatment technology because it has been demonstrated to be effective and can be generated from shipboard sources.

Technology Description

Several chemical biocide options are being evaluated for use against NIS in ballast water. With the exception of ozone, most other biocide treatments (see fact sheet *Chemical Biocides- Organic Acids and Other Disinfectants*) are currently considered unfeasible for large scale tanker application due to their overall corrosive nature and the resulting potential risks to ship and crew from storage and handling. Ozone is commonly used to treat wastewater, swimming pools, and other fresh water sources. Ozone can be readily generated aboard a ship, by stripping oxygen out of ambient air. Ozone, when combined with pretreatment such as filtration, shows promise and has been full-scale tested aboard the *Tonsina*, an Alaska Tanker Company ship operated for British Petroleum.

The recent full-scale ozone treatment project aboard the *Tonsina* involved a $3 million retrofit to support over 2,000 stainless steel ozone diffusers. The study's objectives were to:

- Determine the disinfection effectiveness of a full-scale ozone system in comparison to ballast water exchange efficiency;
- Determine the acceptability of discharging treated ballast water using whole effluent toxicity testing, and to determine the latent toxicity of the subsequent ballast water discharge; and
- Obtain operational experience with the prototype ozone system in order to implement further system improvements.

The study concluded that ozonation has the potential for being an effective and safe technology for treatment of nonindigenous species in ballast water. It was concluded that:

- Using the prototype system, 5-10 hours of ballast water ozonation resulted in 71-99% mortality of most marine phytoplankton, zooplankton, and bacteria depending on the amount of ozone gas delivered to individual ballast water tanks over time. Benthic organisms (e.g. crabs, amphipods) appeared to be relatively resistant to ozone treatment. The study noted that the overall system effectiveness may have been under-estimated because of the longer-term residual toxicity of bromine.
- The organism mortality efficiency was greater than that achieved (64% on average) using empty-refill ballast water exchange on the same vessel.
- Field and laboratory experiments suggest that significant organism mortality can be achieved once concentrations of ozone-produced oxidants reach 1-3 mg/l (as chlorine equivalents) or when oxidation-reduction potentials reach levels of 700-800 millivolts (mV).

- Bromine was the ozone-produced oxidant that was most likely responsible for organism mortality. Bromine may also persist at toxic concentration in ballast waters 1-2 days following ozonation depending on storage conditions and exposure to sunlight.

Technology Advantages

Unlike many other treatment options, chemical treatment has been demonstrated to be very effective in killing a broad range of organisms, particularly at the microbial and cyst stage. It is a proven technique in land-based, fresh water industrial and municipal systems. Ozone is commonly used to treat wastewater, swimming pools, and other fresh water sources.

Technology Challenges

Installation of ozone generating plants to treat ballast water aboard a tanker will face all the technology challenges associated with retrofitting a new technology aboard an existing vessel; these challenges are well documented in the pilot study aboard the *Tonsina*. While ozone has been proven extremely effective for microscopic organisms, large species, including the Chinese Mitten Crab experienced a 100% survival rate. Using ozone to solve the complete NIS problem for PWS will require coupling ozone treatment with another physical treatment method, such as filtration to address the full range of NIS of concern.

Cost

Shipboard ozone plants are estimated to cost between $400K and $20,000,000. Chemical treatment retrofit requires installation of stainless steel or other corrosion resistant storage, handling, and distribution piping. Additional capital costs would include physical separation to remove mature NIS where necessary.

United States Regulatory Requirements

The United States does not require chemical biocide treatment of ballast water at this time.

Ozone Treatment: Rating as a Viable NIS Treatment Method[1]

NIS Treatment Rating System For PWS	Rating for Ozone Treatment	Rating Description
Safety	**	Slight, manageable safety risk
Environmental	***	Technology removes NIS and has no negative impact on the environment
Efficacy	**	Technology is effective, but may not be effective for all NIS of concern
Cost	**	Technology can be adapted at a reasonable cost
Practicality	**	Slight impact on current operations; technology requires some training

Rating is based on a three star system; three stars is the highest rating, one star is the lowest rating.

Status of Technology for Port Valdez & Alaska Crude Oil Tanker Trade

Oil tankers that deliver ballast water to the Valdez Marine Terminal in Port Valdez, Alaska do not currently employ formal or consistent chemical treatment of ballast water for NIS. British Petroleum, in cooperation with University of Washington School of Aquatic and Fishery Sciences spent $3 million to retrofit their oil tanker *Tonsina* for ozone treatment research and development on Puget Sound waters. While the study proved extremely effective for microscopic organisms, large species, including the Chinese Mitten Crab experienced a 100% survival rate. Research on the viability of ozone treatment coupled with filtration or other physical separation continues.

[1] See PWSRCAC "Technology Viability Rating System" FACT SHEET for an explanation of the rating system.