Ballast tanks

Thermal Treatment

Purpose
High temperatures are commonly used to sterilize water. Thermal treatment is a technique that could be used to kill nonindigenous species (NIS) in ballast water by heating the ballast to a high enough temperature to kill NIS before the water is discharged. This method is currently being examined as an on-board treatment option; however, thermal treatment can also be used in an on-shore ballast water treatment facility.

Technology Description
Thermal treatment of ballast water onboard tankers is currently being explored as a viable option for treating ballast water during vessel transit. Options for heating ballast water onboard a vessel include: (1) use of waste heat produced by the ship’s engines and (2) use of heat created by auxiliary boiler systems installed aboard the vessel. Current research is focused on the use of waste heat produced by ship engines since it may provide the most cost-effective technical solution.

The diagram to the right illustrates how a heat exchanger can be used aboard a vessel to capture waste engine heat to warm ocean ballast water to temperatures capable of killing NIS.

More expensive systems involve installation of additional boilers and fuel tanks specifically designed to heat ballast water while in transit as shown in the simplified schematic to the left. In this situation, additional heating capacity is installed aboard the vessel to heat the ballast water to a higher temperature than can be achieved by scavenging the ship engine’s heat using a simple heat exchanger. Additional heating capacity may be required to effectively kill a wider range of NIS in the ballast water. Installation of an auxiliary boiler system aboard a tanker would include installation of the boiler and a suitable pretreatment filtration system, plumbing modifications, construction of deck shelter to house system if no below-deck location is available, plumbing for a bypass system in the event of a failure, routing of fuel lines and potential installation of an additional fuel tank, and routing of the boiler exhaust to main stack or other exhaust system.

On-board trials have demonstrated that waste engine thermal systems can increase ballast water temperatures to 37-38°C (98-100°F) and are effective in killing a majority of NIS. Higher temperatures are required to effectively kill all microorganisms including cysts. The length of time ballast water is exposed to target temperatures affects the organism mortality. Longer exposure times result in higher kill rates. Optimal exposure times are species dependent and must be researched and tested for specific applications: however, current research shows typical exposure times to range from under a minute to more than four hours to achieve effective kill rates.

To date, most research on the effectiveness of thermal treatment at different temperatures and incubation periods comes primarily from Australia where several ships were retrofitted with heat exchangers or boiler systems to field test the viability of thermal treatment of ballast water aboard a vessel. Overall, researchers are finding the viability of thermal technology design will vary depending on the ship’s heat balance, engine cooling system design, availability of steam, and the additional equipment and degree of retrofit required.

Technology Advantages
Waste heat from the ship’s main engine is typically pumped overboard as a waste product. Thermal treatment offers a safe and cost effective method for treating NIS in ballast water, using onboard resources, and recycling waste heat. While many treatment methods are effective in killing water-borne NIS, few are effective at killing NIS embedded in sediment which has accumulated at the bottom of the ballast water tanks. Thermal treatment has the added advantage of heating sediment contained in the ballast water and killing NIS that reside in the sediment. Thermal treatment technology occupies an acceptable onboard footprint and has been demonstrated to effectively kill the majority of organisms in ballast water.
**Technology Challenges**

In transit, treatment with heat can be a challenge for vessels with large volumes of ballast water because adequate time is needed to treat all of the water. Oil tankers’ voyage durations are typically long enough to make thermal treatment worth further investigation. The amount of waste heat available from the existing ship engines may determine whether the technology is economically viable, as installation of auxiliary boilers to supplement the heat requirements may be cost prohibitive. While temperatures reached using waste heat from the ship engines are sufficient to kill many NIS, the temperature reached is not adequate to kill most human pathogens, viruses, or cysts. If human pathogens, viruses, or cysts are a ballast water NIS concern, installation of auxiliary boilers to supplement the heat requirements will be required.

Researchers suspect, but have not fully documented, that heating of ballast water may increase system corrosion and promote the growth of algae that thrive in the heat. The literature warns that heating water in ballast tanks of older ships may create serious safety problems due to the unknown effects of local expansion or corrosion. Space requirements make heat treatment installation impossible in retrofits and will require careful planning for installation on a new vessel, particularly where additional boilers are required. Fuel consumption for high flow systems is estimated at over 475 gallons per hour to raise the water temperature from 40F to 150F.

**Cost**

Thermal treatment costs are not yet fully known and are extremely vessel specific. One of the key cost drivers is what temperature is required to effectively kill the NIS of concern. If the NIS can be treated by the temperature achieved by scavenging ship engine heat, a cost-effective retrofit may be achieved. If higher temperatures are required to treat the NIS, auxiliary boiler systems may be required and will substantially increase the treatment cost.

Retrofits for systems relying on ship engine waste heat would likely require installation of more efficient heat exchangers, piping, pumps, and valves. Boiler installation cost estimates will be vessel specific; however, one study provides a little insight on the range of costs to be expected. Ballast Water Secondary Treatment Technology Review by Battelle Labs\(^1\) estimates costs at $60K-200K for boiler installation; $28-45K for plate heat exchangers, and $88K for recovery heater heat exchanger. Supplemental energy may also be necessary and would require installation of additional fuel tanks.

**United States Regulatory Requirements**

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

**Thermal Treatment: Rating as a Viable NIS Treatment Method\(^2\)**

<table>
<thead>
<tr>
<th>NIS Treatment Rating System For PWS</th>
<th>Rating for Thermal Treatment</th>
<th>Rating Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>**</td>
<td>Slight, manageable risk increase</td>
</tr>
<tr>
<td>Environmental</td>
<td>***</td>
<td>Technology removes NIS and has no negative impact on the environment</td>
</tr>
<tr>
<td>Efficacy</td>
<td>**</td>
<td>Technology is effective, but may not be effective for all NIS of concern</td>
</tr>
<tr>
<td>Cost (using ship engines)</td>
<td>**</td>
<td>Technology can be adapted at a reasonable cost</td>
</tr>
<tr>
<td>Cost (using boiler system)</td>
<td>*</td>
<td>Technology is still under development; cost is not well understood</td>
</tr>
<tr>
<td>Practicality (using ship engines)</td>
<td>***</td>
<td>Slight impact on current operations; technology requires some training</td>
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</table>

*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 ship ballast water to the Valdez Marine Terminal in Port Valdez, Alaska do not treat ballast water for NIS. The ships are not currently equipped to conduct thermal treatment of ballast water. This technology has not be tested or researched by the Alaska Crude Oil Tanker Owners or Operating Companies to date.

\(^1\) [http://www.nemw.org/Balsurv_Contents.htm](http://www.nemw.org/Balsurv_Contents.htm)

\(^2\) See PWSRCAC “Technology Viability Rating System” FACT SHEET for an explanation of the rating system.