Electrolytic disinfection has been effectively used for more than thirty-five years to control microorganisms in industrial and municipal waters. The technology has a strong history in marine and offshore markets and is now proven to be highly effective for the treatment of ballast water. The technology is very effective against a wide range of nuisance-causing organisms and has proved to be a viable solution to help ship owners and managers comply with the most stringent ballast water regulations.

While the chemistry used by ballast water treatment systems for electrolyzing seawater is similar, commercially available technologies differ, resulting in variations in everything from system footprint and installation costs to energy usage, disinfectant quality and overall system efficacy. These differences — and the efficacy of electrolytic disinfection overall vs. alternative ballast water treatment technologies — are not yet reflected in all ballast water industry trade literature, so a review of the technology may be instructive.
WE UNDERSTAND BALLAST WATER TREATMENT

While electrolytic ballast water disinfection systems share the same basic chemistry for electrolyzing seawater, commercially available electrolytic disinfection technologies differ significantly.

**Electrolytic disinfection: An operational review**

This safe, non-hazardous, on-demand generation of hypochlorite produces a 0.1 wt/vol active ingredient (50 times weaker than household bleach) from seawater. Since the hypochlorite is generated on-demand and in situ, no storage is required aboard ship. A residual biocide disinfectant remains in the ship’s ballast water tanks during the voyage — making discharge operations much simpler and eliminating regrowth of organisms during transit.

The electrolytic reaction is simple — using seawater and electricity to produce the disinfection solution. The initial reaction takes place in an electrolytic cell composed of anodes and cathodes using DC power to provide the energy. The current passes through the saltwater solution between the plates, driving the electrolytic reactions at the anode and cathode.

Anodes are typically titanium sheets or expanded titanium metal encased with a precious metal oxide coating to lower the discharge potential and preferentially make the oxidant instead of oxygen. The cathode is typically titanium or Hastelloy® metal to provide a long life and stable electrode. In a commercial electrolytic ballast water treatment system, multiple electrodes can be contained in one electrolyzer to boost production, or more than one electrolyzer can be combined to treat larger flow rates. Electrolytic ballast water treatment system manufacturers make use of different electrodes (size, shape and coating), electrolyzer geometry and electrolytes. The type of electrolytic cell coating has implications on warranty, system maintenance, disinfectant quality and efficiency and could cause some systems to stop working all together.

The operating cost for electrolytic systems, driven by the cost for electricity to generate the active ingredients, is very low since the oxidant is generated from seawater.

**Performance in extreme water conditions**

All in situ sodium hypochlorite-based ballast water treatment systems share common treatment principles. Yet, due to significant variations in system design, not all are capable of performing in extreme water conditions such as cold or low salinity uptake areas.

Electrolytic technology functions optimally above 15 degrees C (59 degrees F) seawater feed. Performance of hypochlorite generation is reduced at water temperatures between 10 to 15 degrees C (50 to 59 degrees F) and the technology does not function at all below 5 degrees C (41 degrees F). Below 10 degrees C, the formation of chlorine hydrate significantly reduces the efficiency of the generator. Below 5 degrees C, the electrolytic product is mostly oxygen with no chlorine generation.

Electrolytic ballast water treatment system manufacturers either pass the entire ballast stream through the electrolytic cells or divert a small side stream from the main ballast line. This diverted stream is used to generate the hypochlorite within the electrolyzers and the biocide is then re-injected into the ballast line. In cold water applications, when the incoming ballast seawater is less than 15 degrees C, the advantage of the treatment of side stream flow is that the stream can be easily warmed to significantly improve the hypochlorite production rate and extend the life of the electrodes.

Electrolytic disinfection technology requires a saline source to generate disinfectant and is not, therefore, ideal for fresh water applications.
Benefits of neutralizing ballast water at discharge
Most manufacturers of electrolytic systems have incorporated a neutralization step in the process during deballasting. All active compounds generated in the electrolytic disinfection process are safely neutralized during deballasting. A safe, easy-to-use, inexpensive reducing agent is injected into the discharge at very low concentrations (1 to 3 ppm) to neutralize the oxidizing species.

By providing a neutralization system in conjunction with an electrolytic system, all oxidants can be neutralized at any time to prevent discharge of the biocide, and the discharge is immediately rendered non-toxic. Neutralization of the water ballast at discharge also saves operating expenses when compared to UV-based technologies. UV has no residual biocide, and re-growth in the ballast water tanks forces the ship owner to also use UV treatment at full power during discharge operations.

System Footprint
Electrolytic treatment systems with a sub-assembly component design allow for installation in available engineering spaces including multiple decks — separate from the main ballast system (pump room). This eliminates requirements for engine room design changes and makes systems suitable for hazardous installations (crude oil, chemical, product tankers and LNG).

Cost benefits of larger capacity electrolytic systems
The capital investment for electrolytic ballast water treatment systems is competitive with alternative treatment technologies for greater than 500 m³/hr of ballast. The capital investment becomes even more favorable for systems designed to treat 1,000 - 3,000+ m³/h of ballast due to savings realized by the ability to scale up production rates.

The electrolytic process lends itself to significantly scaling up production rates to meet the demands of large ships with high ballast flow rates (>3,000 m³/hr) or poor incoming ballast water quality. This is accomplished by simply increasing the size and number of plates in each electrolyzer. For example, an electrolytic process to treat 500 m³/hr of ballast may require 10 m² of floor space. However, an electrolytic process to treat 5,000 m³/hr of ballast, such as that offered by the BALPURE® ballast water treatment system from Severn Trent De Nora, may require only 25 m². Therefore, there is an economy of scale, with a 10-fold treatment capacity increase requiring only a 2.5-times increase in required space and similar associated cost.

The operating and capital cost savings resulting from scaling up electrolytic ballast water treatment systems can be significant. This is especially so when compared to other ballast water treatment systems that simply replicate their base model design in order to treat increased flow rates, which leads to an inefficient use of space and increased costs and system complexity.
Electrolytic system safety
Some electrolytic treatment system designs are inherently safer than others. For example, some manufacturers have increased the safety of their systems by incorporating a hydrogen management system to dilute and vent the by-product of the electrolytic process rather than discharging it into the ballast tank. Such safety features also enhance system operation and efficacy, helping to make electrolytic systems among the safest, most cost-effective ballast water treatment technologies currently available while providing significant environmental benefits in preventing the transfer of non-indigenous species.

While electrolytic ballast water disinfection systems share the same basic chemistry for electrolyzing seawater, commercially available electrolytic disinfection technologies differ significantly. Understanding the technical and commercial performance criteria of the various electrolytic ballast water treatment technologies is critical to the equipment selection process.

For more information on BALPURE® ballast water treatment system visit www.balpure.com