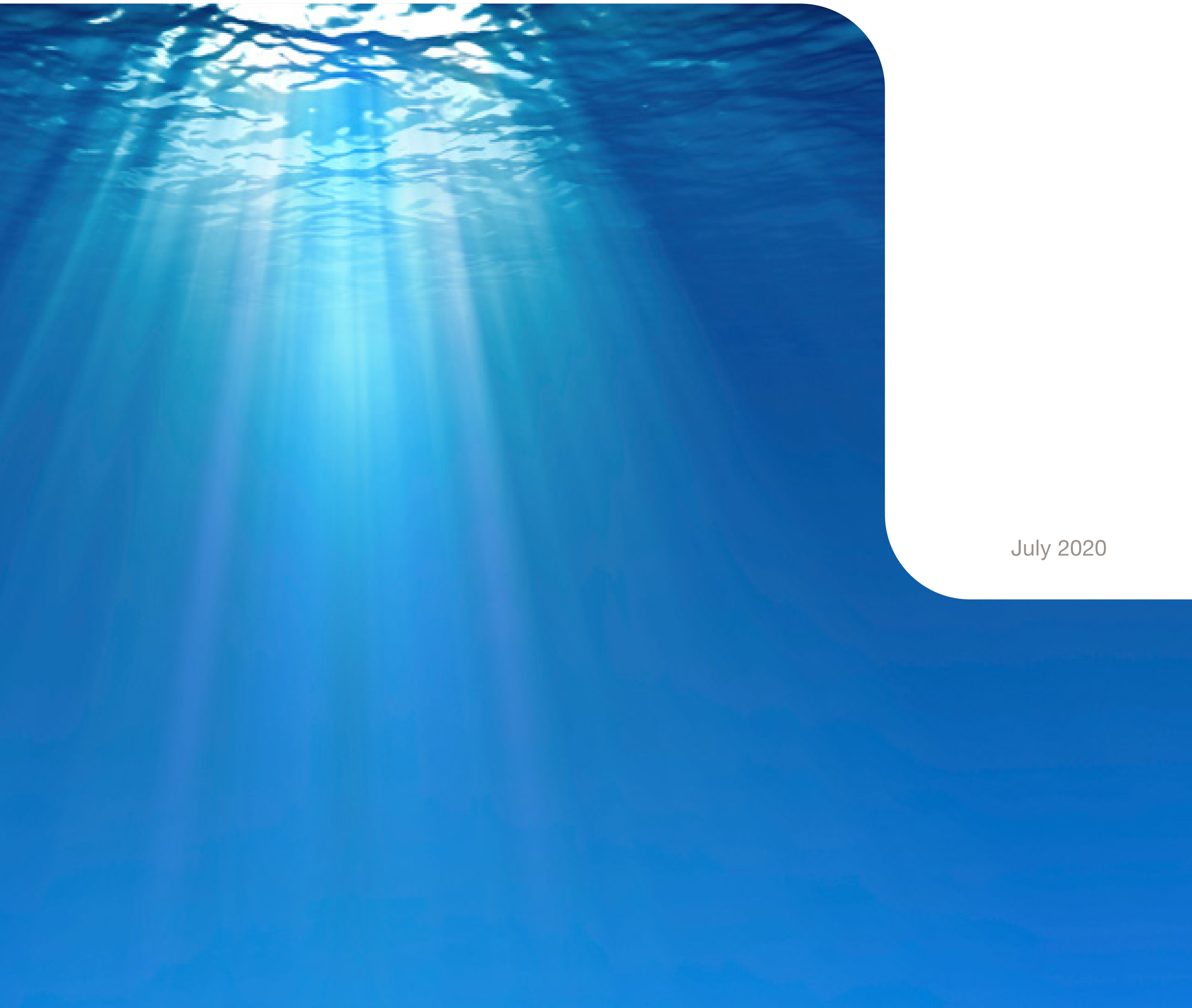
WHITE PAPER

# Comparing UV and electrochlorination

## Achieving peace of mind and economy in ballast water treatment



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# Overview

Common wisdom once held that UV ballast water treatment systems were simpler and better for smaller ballast water flows, while electrochlorination systems were more practical for larger flows. In recent years, however, there has been evidence of a shift in thinking. Today it is not uncommon for UV to be chosen in any flow range.

A clear reason for this is the fact that even large-flow UV treatment systems can now be compact and cost-effective. Through larger UV reactor sizes and other advances, UV solutions such as Alfa Laval PureBallast 3 have put themselves on a highly competitive footing with electrochlorination.

With factors like footprint now largely equal among large-flow systems, others come into sharper focus. Today many shipowners are finding reason to re-examine the safety, complexity and cost issues associated with electrochlorination. This white paper provides a brief overview of those issues and their implications.

# Introduction

UV treatment and electrochlorination have been the dominant technologies for ballast water treatment since long before the IMO Ballast Water Management Convention entered into force. UV treatment uses ultraviolet light to inactivate organisms as they pass through a reactor, whereas electrochlorination passes an electric current through saline water to produce oxidizing disinfectants. These disinfectants are active substances that inactivate the organisms in turn.

Both technologies are proven and simple in principle. However, electrochlorination involves a wide range of safety, logistical and cost considerations that UV treatment does not. As UV solutions continue to grow smaller and more cost-effective, these considerations are leading many to re-evaluate electrochlorination's merits – even for large flows.

# Protecting the crew and vessel

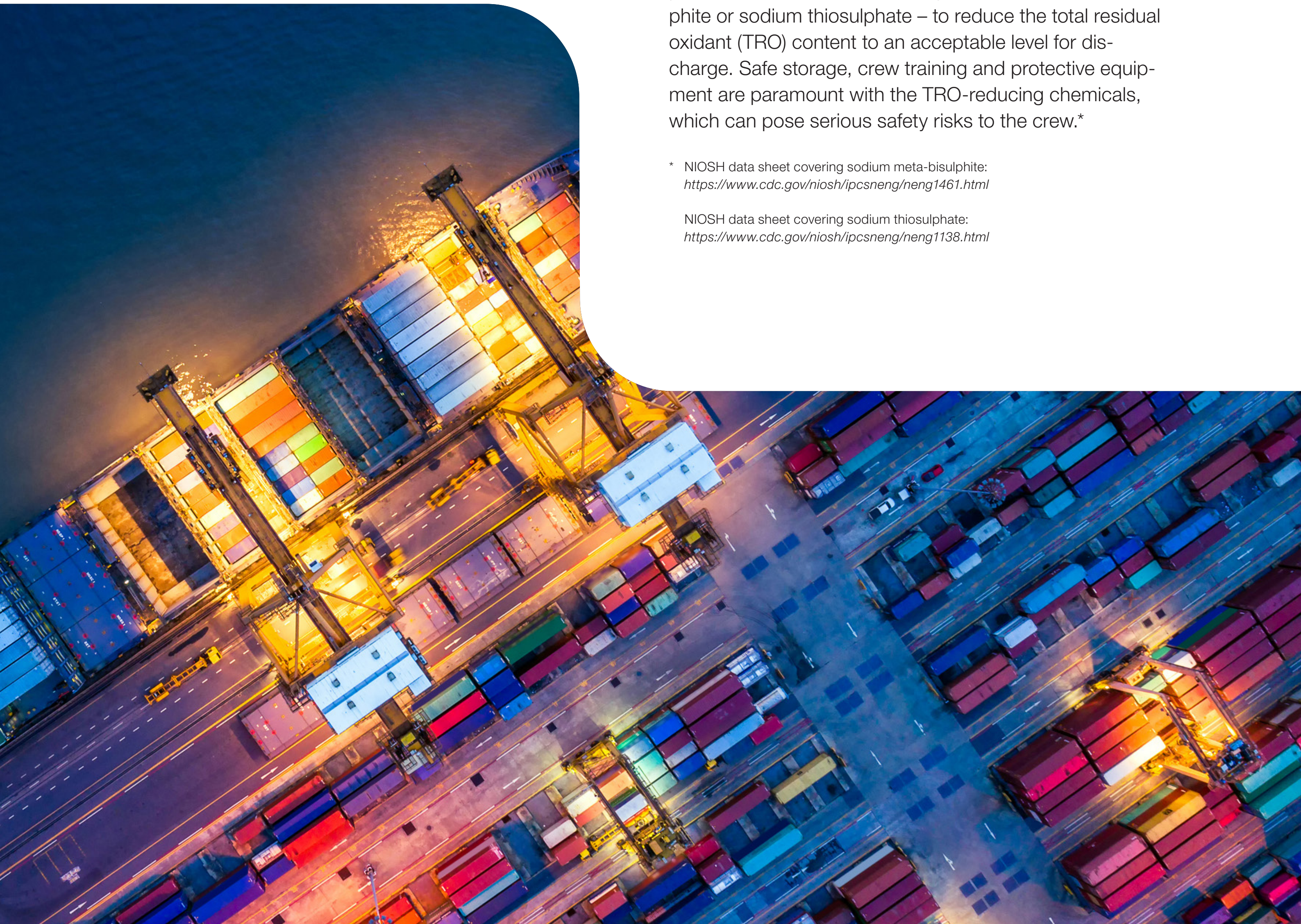
One of the primary issues associated with electrochlorination is the safety of the crew and vessel. The process of electrochlorination generates not only chlorine, but also hydrogen gas. Chlorine is toxic and corrosive in nature, which means it poses both an immediate hazard to the crew and a long-term risk to ballast water tank coatings. Hydrogen, meanwhile, poses an explosion risk.

Under normal operation, the chlorine and the hydrogen gas should dissolve in the water, producing the disinfecting oxidants hypochlorite and hypobromite among other substances. However, the electrochlorination of seawater involves a myriad of reactions that cannot be fully anticipated. The potential for even small amounts of remaining hydrogen gas, for example, makes ventilation and other safety measures essential. No such measures are required with a UV treatment system.

Moreover, the chemical concerns associated with electrochlorination go beyond the disinfection of the ballast water itself. Following disinfection, there is generally a post-treatment needed – usually with sodium meta-bisulphite or sodium thiosulphate – to reduce the total residual oxidant (TRO) content to an acceptable level for discharge. Safe storage, crew training and protective equipment are paramount with the TRO-reducing chemicals, which can pose serious safety risks to the crew.*

* NIOSH data sheet covering sodium meta-bisulphite: *https://www.cdc.gov/niosh/ipcsneng/neng1461.html*

NIOSH data sheet covering sodium thiosulphate: *https://www.cdc.gov/niosh/ipcsneng/neng1138.html*



# Complexity in managing TRO levels

Crew safety aside, managing TRO levels can prove complicated for owners of electrochlorination systems. The post-treatment chemicals are needed to reach a compliant TRO discharge level within a reasonable time, as more time would be required for the TRO content to decay naturally. However, the TRO level is determined by a sensor value. To avoid over- or underdosing of the chemicals, the readings from this sensor must be accurate and correctly interpreted.

The difficulty is compounded by the TRO sensor's own sensitivity. Prone to corrosion, the sensor must be cleaned with additional chemicals every few months and have its alarm mechanism calibrated frequently. In a 2017 study by the American Bureau of Shipping, in which 62% of electrochlorination system owners reported hardware failures, a significant number of these failures were related to the TRO sensor. In the same study, situations where the dosing of TRO-reducing agent was either too high or too low for deballasting were not uncommon.

# Health and environmental threats from DBPs

A potentially greater concern than TRO levels is the creation of disinfection by-products (DBPs). These are compounds formed during electrochlorination by the oxidation of organic matter and other substances present in seawater.

In studies of drinking water chlorination – an application with significantly fewer variables than ballast water treatment – many different types of DBPs have been identified. These studies have shown potential links not only to cancer, but also to mutation and repro- ductive difficulties. Due to the enormous quantities of organic matter and halides it contains, seawater may produce DBPs in far greater number.

It is important to remember that DBPs are not neutralized by the sodium meta-bisulphite or sodium thiosulphate used to reduce TRO levels. DBPs persist in the ballast water even after post-treatment, which means they may pose hazards to marine organisms or human health when discharged. The threats may be direct, or they may arise through the bioaccumulation of DBP toxins in the environment.

# Challenges in handling and stocking chemicals

Even if the potential hazards of electrochlorination are ignored, working with chemicals involves logistical issues that UV treatment does not. Crew training is naturally important for safety in chemical handling, but it is also needed to create an understanding of properties such as shelf life. Otherwise, mishaps can occur that make the chemicals unusable, such as solidification through exposure to humidity.

In addition, the chemicals themselves may be difficult to get on board. In the aforementioned study by the American Bureau of Shipping, 23% of electrochorination users reported that consumables were a challenge, either due to stocking difficulties or because of permissions needed for the required chemicals in certain ports.

Such challenges are significant in light of recent U.S. Coast Guard (USCG) clarifications. The USCG has specifically stated that a lack of required consumables does not justify the use of an alternate ballast water management method.

# Lower OPEX with UV treatment

Chemicals also mean costs over time, which impacts the OPEX of electrochlorination systems. The faster TRO levels need to be reduced, the greater the use of chemicals and the corresponding increase in OPEX.

In addition, electrochlorination may involve substantial energy costs as a result of water heating. Whereas UV treatment is unaffected by water temperature, the effectiveness of electrochlorination is dependent upon it. Vessels that operate in colder waters may thus need to raise the seawater's temperature for electrochlorination to proceed efficiently.

Given that the ballast water treatment system will be used for the lifetime of the vessel, these factors compound over many years. For many shipowners with a long-term perspective, OPEX alone is enough to swing the balance clearly in UV treatment's favour.

## The influence of chemicals on OPEX

### Example 1: LNG tanker

| | |
|---|---|
| Ballast water volume: | **936,600 m$^3$/year** |
| Residual TRO: | **1.5 PPM** |
| Chemical consumption (12 cycles/year): | **≈ 6.6 T** |
| Cost of chemicals: | **1.25 USD/kg** |
| Yearly cost of chemicals: | **8,250 USD** |
| Yearly cost of chemical transportation: | ***South Asia:*** **7,900 USD**<br>***Middle East:*** **11,200 USD** |
| TOTAL cost per year: | ***South Asia:*** **≈ 16,000 USD**<br>***Middle East:*** **≈ 19,500 USD** |

### Example 2: Aframax shuttle tanker

| | |
|---|---|
| Ballast water volume: | **2,850,000 m$^3$/year** |
| Residual TRO: | **5 PPM** |
| Chemical consumption (50 cycles/year): | **≈ 67 T** |
| Cost of chemicals: | **1.25 USD/kg** |
| Yearly cost of chemicals: | **83,750 USD** |
| Yearly cost of chemical transportation: | ***South Asia:*** **80,500 USD**<br>***Middle East:*** **113,900 USD** |
| TOTAL cost per year: | ***South Asia:*** **≈ 165,000 USD**<br>***Middle East:*** **≈ 195,000 USD** |

### Example 3: MR tanker

| | |
|---|---|
| Ballast water volume: | **552,000 m$^3$/year** |
| Residual TRO: | **1.5 PPM** |
| Chemical consumption (12 cycles/year): | **≈ 4 T** |
| Cost of chemicals: | **1.25 USD/kg** |
| Yearly cost of chemicals: | **5,000 USD** |
| Yearly cost of chemical transportation: | ***South Asia:*** **4,800 USD**<br>***Middle East*:** **6,800 USD** |
| TOTAL cost per year: | ***South Asia:*** **≈ 10,000 USD**<br>***Middle East:*** **≈ 12,000 USD** |

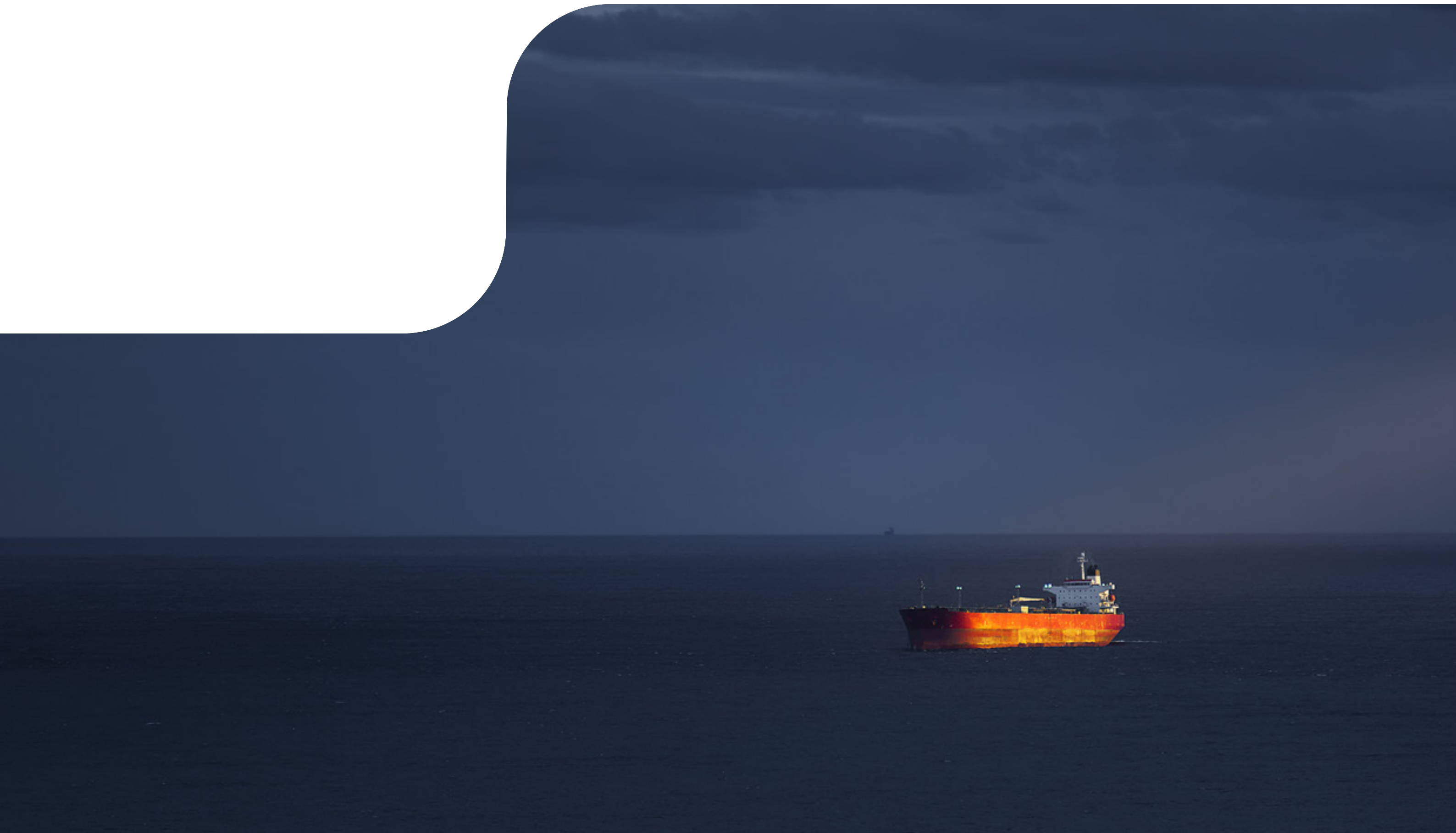
The examples above contain illustrative figures based on discussion with a number of different shipowners.

# Taking all CAPEX into account

In fact, even the CAPEX of a modern UV treatment system can be lower than that of an electrochlorination system. This is true for large-flow systems as well, especially when the entire installation is considered. Most often, there are costs for equipment and vessel modifications that fall outside the scope of the electrochlorination system – and are therefore not reflected in the supplier's offer.

Whereas UV treatment systems have little impact on the rest of the vessel, electrochlorination systems require additional ventilation and equipment such as hydrogen traps. Due to the water temperature issues described above, they may also require further installed heating capacity, even if waste heat recovery is used as a heat source. Because ballast water treatment occurs mainly during harbour stays, the waste heat recovery systems on board may be insufficient to support it.

In many cases, electrochlorination also requires a tank for storing high-salinity water. Just as it is linked to temperature, electrochlorination's effectiveness depends on the water's salt content. Because adding a tank requires more space and CAPEX, it is sometimes suggested to use the existing aft peak tank (APT) for this purpose. Regulating the amount of saline water in the APT can be complicated, however, and its use could affect the vessel's trim and fuel efficiency, producing a negative influence on OPEX.



# Capacity now on equal footing

What previously spoke in favour of electrochlorination was capacity, given that older UV treatment systems needed an infeasible number of reactors for flows above 1000 m3/h. Today, however, larger UV reactor sizes allow solutions like Alfa Laval PureBallast 3 to handle flows many times higher. In fact, the footprint of UV systems can now be smaller than that of electrochlorination systems.

In the case of PureBallast 3, individual systems can be configured for up to 3000 m3/h. This means that one system is insufficient for a VLCC, for example, which may require a ballast water flow of 6000 m3/h. In such a situation, however, two ballast water treatment systems can be installed on the vessel to support the needed flow. These systems will then be operated in parallel, with no detrimental effect. On the contrary, a dual-system approach has the added benefit of redundancy, allowing one system to support the vessel's ballasting and deballasting operations if the other system should fail.

For one specific vessel category, bulk carriers, the capacity issue is more complex. Bulkers often load cargo twice as fast as they unload it, which means that deballasting occurs at twice the ballasting speed. Unlike electrochlorination systems, which treat only the intake water, UV systems treat the water during both ballasting and deballasting, which has resulted in overcapacity for the latter. Today, however, UV systems like PureBallast 3 can be configured for asymmetric flows. Because filtration is not needed when deballasting, a smaller filter can be installed – resulting in a smaller footprint, less OPEX and reduced capital investment.

# Conclusions

Since UV treatment systems are now physically competitive even for large flows, there is ample reason to weigh their other benefits against the potential downsides of electrochlorination. Yesterday's truth, that electrochlorination is more appropriate for large flows, is well worth questioning today.

With no hazardous chemical handling, no active substances to monitor, lower OPEX and potentially lower CAPEX and installation expenses, UV treatment systems allow shipowners to avoid both risks and costs. As a result, they may offer more peace of mind and greater economy in both the short and the long term.

# References


- American Bureau of Shipping. *Best Practices for Operation of Ballast Water Management Systems – Identified during ABS 2nd BWMS Workshop, Houston.* August 2017.
- DNV-GL. *Ballast water management: Insights into the regulatory status, applicable treatment technologies and compliance solution.* September 2016.
- Gonsior, Michael; Mitchelmore, Carys, Heyes, Andrew; Harir, Mourad; Richardson, Susan D; Petty, William Tyler; Wright, David A and Schmitt-Kopplin, Philippe. Bromination of Marine Dissolved Organic Matter following Full Scale Electrochemical Ballast Water Disinfection. *Environmental Science & Technology,* no. 49 (2015): 9048–9055.
- Werschkun, Barbara; Höfer, Thomas and Greiner, Matthias (editors). *Emerging Risks from Ballast Water Treatment.* Federal Institute for Risk Assessment. Berlin: BfR Wissenschaft, 2012.

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