Operational Limitation in Ballast Water Management

~ How to meet the discharge standards without filter unit

Techcross Technical White Paper

USCG BWM Regulatory

Separate from the Ballast Water Management (BWM) Convention of the International Maritime Organization (IMO) enacted in February 2004, the U.S. Coast Guard (USCG) also enacted the BWM Regulatory in June 2012 and enforced across the coast of the United States in December 2013. Therefore, all vessels entering the United States must treat the ballast water through the type approved BWMS by the USCG. In order to satisfy the USCG's BWM Regulatory, BWMS must meet the discharge criteria as shown in the Table 1 below.

Size of Microorganisms	Over 50㎛	Less than 10 units per 1m^3
	10㎛ ~ 50㎛	Less than 10 units per 1㎖
	Less than 10㎛	Vibrio cholera, Escherichia coli, Enterococci
Types of Bacteria	Vibrio cholera	Less than 10 cfu per 100㎖
	Escherichia coli	Less than 250 cfu per 100㎖
	Enterococci	Less than 100 cfu per 100㎖

Table 1. Ballast Water Discharge Standard

All BWMS have operation limitations to meet the biohazard conditions mentioned in the discharge criteria. Among them, the holding time is the minimum time required from ballasting to de-ballasting to meet the biohazard conditions, which can directly affect the ship's sailing schedule. Especially in the U.S., where there are many short sailing routes, the holding time restrictions are directly linked to the shipping revenue, which makes it susceptible. Therefore, most of the makers with the USCG type approval (TA) are using various management systems in order to mitigate operating restrictions by achieving zero holding time.

Status of USCG TA Obtained BWMS

As of the end of June 2019, a total of 20 BWMSs had obtained USCG type approval, with more than half of them applying an electrolysis system. Interestingly enough, 18 companies use filters, whether it's electrolysis technology or UV technology.

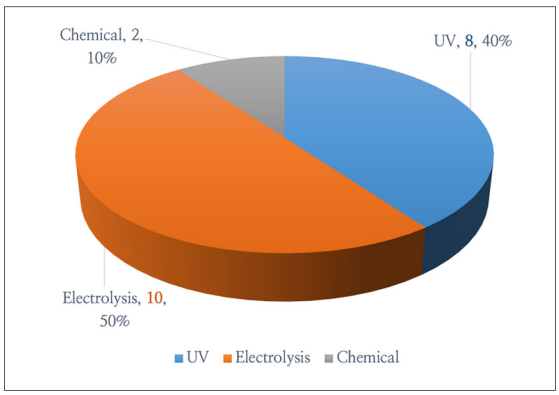

Figure 1. Approval Status of USCG TA Technology

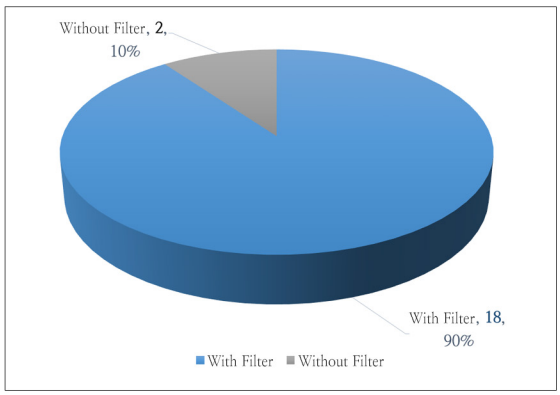

Figure 2. Filter Implementation Status Among USCG TA System

Filter Unit in BWMS

Normally, filters in BWMS function as the primary filtering source to sift out microorganisms over 40㎛ or 50㎛. Microorganisms over 40㎛ or 50㎛ are hard to annihilate due to high resistance. Therefore, high efficiency can be achieved when the smaller microbes are treated secondarily after the first treatment with the filters. If the filters are not available, alternatives mentioned in Table 2 can be applied. However, there is little chance of development of the filter-free system since the filters available are approved as the primary filtering source. Therefore, these alternatives should be noted as a hypothetical scenario.

Treatment	Alternatives	Hypothetical Scenario
UV	Increase in UV lamps	Enlargement of the unit size
	Increase in UV dosage	Increase in electricity consumption
	Increase in UV irradiation Time	Increase in ballasting time
Electrolysis	Increase in the number of electrodes	Enlargement of the unit size
	Increase in electrical strength	Increase in electricity consumption
	Generation of high-concentrated TRO	Risk of hydrogen gas
		Increased environmental hazards with increased disinfection by-products
Chemical	Increase in chemical input	Requirement of larger storage space
		Safety problems in storage and melting process
		Increase in ballasting time

Table 2. Alternatives and Hypothetical Scenarios when Filters Are Not Applied

With the usage of filters, problems in hypothetical scenarios can be solved. However, additional costs for footprint, screen filters and their spare parts, and maintenance were incurred. Although there will be differences among filter companies, additional factors mentioned in Table 3 should be considered.

Price	USD 35,000
Footprint	Over 1.12㎡
OPEX	USD 10,000 per year
Maintenance Period Cost	Every 2 months (small parts) or Every 2.5 years (screen, nozzle, etc.) USD 2,600 per year

Table 3. Considerations When Applying Filter Units (1,000 tons standard)

No Filter Approved System, ECS

Of the 2 systems without filters, the ECS of Techcross is the only system that meets the criteria of USCG TA, using mainstream electrolysis technology unlike the other 18 systems that selected filters for easy secondary treatment. In addition, it is also noteworthy that ECS is not a combined treatment method like other systems, but is a single treatment method that requires one step for BWMS.

ECS is characterized by the direct processing process, which ballast water passes through the electro chamber as the ballast water enters the vessel. Therefore, uniform sterilization effect can be expected by electrophoresis applied to all ballast water. Also, TRO induced from electrolysis process remains in ballast water for a period of time, which helps the maximum sterilization. The following is the operational limitations for the revised USCG TA on June 14, 2019.

Salinity	NA
Hold Time	-Brackish/Marine Water (〉1 PSU) : NA -Fresh Water (〈1 PSU) : 48 Hours
Electrolyte Feed Temperature	0-36℃
Electrolyte Feed Salinity	1.5 PSU
TRO	-Fresh/Brackish Water (〈28 PSU) : 7.5mg/L -Marine Water (〉28 PSU) : 7.8mg/L

Table 4. ECS Operational Limitations

On Table 4, it is noted that the ECS holds almost same and even less operational limitations compared to the systems with filters. The initial type approval was obtained in June 2018 and its 120 holding time was also changed to zero holding time in this amendment. Only fresh water under 1 PSU with very thin salinity requires 48 hours of holding time. However, ECS has the advantage of having no filter, so there is no pressure loss caused by filter and no additional cost and effort is required to maintain the filter.

How ECS Met The Criteria Without Filter

The key element that allows equivalent or better processing results without filter is the self-developed electrode by Techcross. Techcross, the company that had been developing electrodes for efficient electrolysis since the land water treatment business, has improved electrode efficiency by switching to the BWMS business. Also, the company improved its own producing capacity by establishing one of the largest factories in the world in 2015, which led to the price competitiveness.

The electrodes produced by Techcross not only use highly reactive catalyst in fresh water or brackish water that lacks chloride, but also improved efficiency via producing crack on the surface of titanium electrode that increases the surface area.

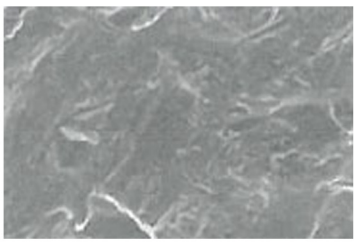

Figure 3. Titanium Electrode Surface

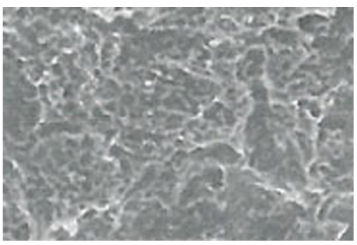

Figure 4. Electrode Surface after Etching

Figure 5. Electrode Surface after Coating

Also, as the BWMS process is repeated, the reaction resistance between the electrodes increases due to the scale electrodeposition phenomenon on the surface of the negative electrode, and also, the consumption of electricity increases to keep the concentration of the oxidizer, which all lead the lifespan of BWMS decrease. In order to solve this problem, the technology of periodically applying reverse currents are implemented. However, the requirement of acid-wash process, electrode life reduction & corrosion due to the use of the steel acid, and discontinuation of the electrolysis are the disadvantages of the technology.

However, Techcross has developed a patented method to reduce the scale of cathode electrodes by coating special substances on the surface of titanium electrodes.

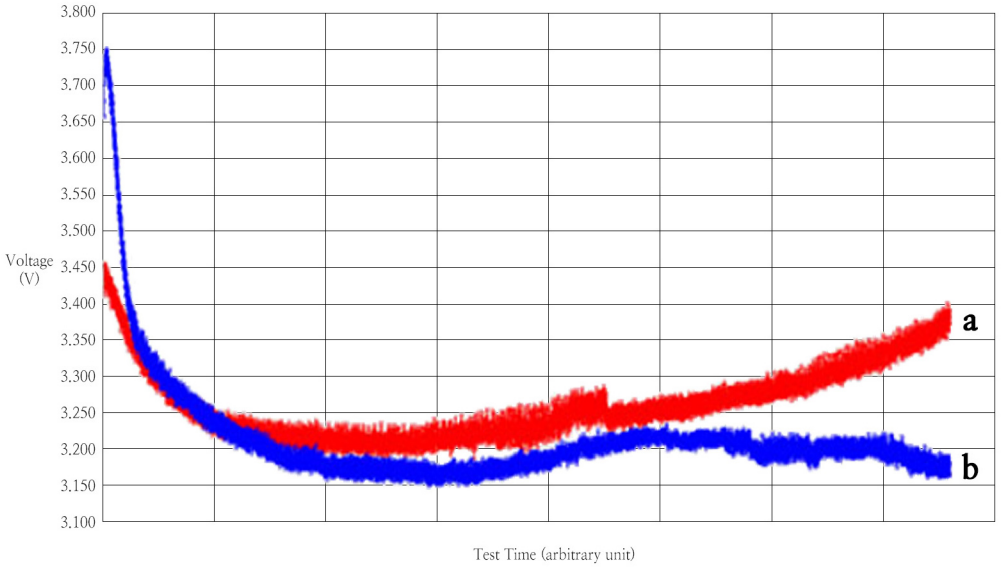

Figure 6. Electrolysis Reaction Results from Reference Electrode and Techcross Electrode

In Figure 6, a comparison between the reference electrode (a) and Techcross electrode (b) shows that the voltage of the reference electrode (a) increases due to the accumulation of the scale over time although similar trends are initially observed. The long-term experiment shows that the Techcross electrodes had anti-scale effect by more than 90% of the normal electrodes. This not only maximizes the efficiency of the electrodes, but also provides economic feasibility with extended lifespan of electrodes. In addition, ECS using direct electrolysis method is also reliable in terms of safety, since there is no risk of hydrogen gas generated by high-density TROs as seen in indirect electrolysis method.

Each BWMS technology has advantages and disadvantages. However, in the process of selecting the system, rather than simply being tied to the availability of certification and price, detailed operation conditions must be considered, taking into account the installation space and all the cases that may occur during the operation.

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