Ballast Water Treatment
Overview of Approved and Available Systems

Jad Mouawad – Owner, Mouawad Consulting
2013-11-01
Agenda

- Ballast Water Treatment Technologies
- Ballast Water Treatment Systems
- USCG Type Approval
Ballast Water Treatment Technologies
Ballast Water Treatment Technologies

- Physical
- Mechanical
- Chemical
Ballast Water Treatment Technologies

Physical

UV
- Low Pressure
- Medium Pressure

Ultrasound

Cavitation

De-oxygenation
- Inert Gas
- Nitrogen

Heat Treatment

Inert Gas

Nitrogen

Ballast Water Treatment – overview of approved and available systems
Ballast Water Treatment Technologies

- Mechanical
  - Filtration
    - Screen filters
    - Disc filters
  - Pressure Drop
    - Hydrocyclones
    - Magnetic separation & coagulation
Ballast Water Treatment Technologies

Chemical
- Electrolysis
  - Electrocatalysis
  - Electrochlorination
- Ozonation
- Chemical injection
  - Sodium Hypochlorite
  - Chlorine Dioxide
  - Other
- High-energy plasma
- Advanced Oxidization
  - TiO₂
  - Ozone + UV
  - Other

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Ballast Water Treatment – overview of approved and available systems 2013-11-01
Ballast Water Treatment Technologies

- AOP: Other
- AOP: Ozone + UV
- AOP: TiO2
- High energy plasma
- Heat Treatment
- N2
- IG
- H2O2
- ClO2
- NaOH
- Cavitation
- Ozone
- Ultrasound
- Electrolysis
- Pressure drop
- Magnetic separation
- Hydrocyclone
- Disc filtration
- Screen filtration
- Medium pressure UV
- Low pressure UV
Ballast Water Treatment Technologies

Filtration

Mechanical

- BWTS w/o
- BWTS with

Filtration

- Screen
- Disc
- Hydrocyclone
- Magnetic

14 Mechanical BWTS
52 Mechanical BWTS

1 Screen
3 Disc
3 Hydrocyclone
2 Magnetic
Ballast Water Treatment Technologies

Filtration

Mesh size

Pressure difference

Working pressure

Disc filters

Screen filters

Hydrocyclones
Ballast Water Treatment Technologies

**Filtration**

Affecting ship performance

- Backflush volume
- Backflush time
- Backflush design
- Backflush outlet pipe diameter
- Backflush pump

Affecting filter performance

- Size of TSS
- Filtration area

Affecting ship performance

- Affecting filter performance
Ballast Water Treatment Technologies

- Low pressure UV
- Medium pressure UV
- Screen filtration
- Disc filtration
- Hydrocyclone
- Magnetic separation
- Heat Treatment
- N2
- IG
- H2O2
- ClO2
- NaOH
- Cavitation
- Ozone
- Ultrasound
- Electrolysis
- Pressure drop
- AOP: TiO2
- AOP: Ozone + UV
- AOP: Other
- Cavitation
- Ozone
- Ultrasound
- Electrolysis
- Pressure drop
- N2
- IG
- H2O2
- ClO2
- NaOH
- Heat Treatment
- Low pressure UV
- Medium pressure UV
Ballast Water Treatment Technologies
Ultraviolet - UV

UV-based systems overview
- Other
- Medium pressure
- Low pressure

- Other: 40
- Medium pressure: 26
- Low pressure: 6

Ballast Water Treatment – overview of approved and available systems

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Ballast Water Treatment Technologies
Ultraviolet - UV

Main parameters

- UV Transmittance
- Flow rate

Affecting UV performance

- TSS, DOC, POC
- Water velocity in the chamber
- Chamber holding time
- Flow entry profile
- Warm up time
- Temperature (only MP)
Ballast Water Treatment Technologies

- AOP: Other
- AOP: Ozone + UV
- AOP: TiO2
- High energy plasma
- Heat Treatment
- N2
- IG
- H2O2
- ClO2
- NaOH
- Cavitation
- Ozone
- Ultrasound
- Electrolysis
- Pressure drop
- Magnetic separation
- Hydrocyclone
- Disc filtration
- Screen filtration
- Medium pressure UV
- Low pressure UV

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Ballast Water Treatment – overview of approved and available systems

2013-11-01
Ballast Water Treatment Technologies

**Electrolysis**

- Other
- Side stream
- Direct flow

**Electrolysis vs. Filtration**

- With filtration
- W/o filtration

![Circle Diagrams](image-url)
Ballast Water Treatment Technologies
Electrolysis

**Deduction 1**

BWTS w/o mechanical separation use direct flow process

- ECS-A: Direct flow
- ECS-B: Direct flow
- AquaStar BWMS: Cavitation + Direct flow
- SmartBallast BWMS: Direct flow
- KTM-BWMS: Cavitation + Direct flow
- HS-Ballast BWMS: Direct flow

**Deduction 2**

All side stream processes use filtration
Ballast Water Treatment Technologies
Electrolysis

Main parameters

- Salinity
- Temperature
- TRO downstream

Affecting performance

- Power input to electrodes
- Production at injection point
- Holding time
- Hydroxyls production
- DOC, POC, TSS
Ballast Water Treatment Technologies

- AOP: Other
- AOP: Ozone + UV
- AOP: TiO2
- High energy plasma
- Heat Treatment
- N2
- IG
- H2O2
- ClO2
- NaOH
- Cavitation
- **Ozone**
- Ultrasound
- Electrolysis
- Pressure drop
- Magnetic separation
- Hydrocyclone
- Disc filtration
- Screen filtration
- Medium pressure UV
- Low pressure UV

**Pressure drop**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Pressure Drop</th>
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<tbody>
<tr>
<td>AOP: Other</td>
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<tr>
<td>AOP: Ozone + UV</td>
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<td>AOP: TiO2</td>
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<td>High energy plasma</td>
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<td>Heat Treatment</td>
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<td>IG</td>
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<td>H2O2</td>
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<td>ClO2</td>
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<td>NaOH</td>
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<td>Cavitation</td>
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<td><strong>Ozone</strong></td>
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<td>Ultrasound</td>
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<tr>
<td>Electrolysis</td>
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<tr>
<td>Pressure drop</td>
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<td>Magnetic separation</td>
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<td>Hydrocyclone</td>
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<td>Disc filtration</td>
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<tr>
<td>Screen filtration</td>
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<tr>
<td>Medium pressure UV</td>
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<td>Low pressure UV</td>
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</table>
Ballast Water Treatment Technologies

Ozonation

Ozonation

- Ozone
- Cavitation + ozone
- Filtration + ozone + UV
- Filtration + ozone

1
2
1
2
Ballast Water Treatment Technologies

Ozonation

- Ozone
  - 2.5 mg/L $O_3$
  - 2.3 mg/L TRO

- Cavitation + ozone
  - 3.0 mg/L $O_3$

- Filtration + ozone
  - 12 mg/L $O_3$

- Filtration + ozone + UV
  - 0.4 mg/L $O_3$
  - 7 mg/L $O_3$
# Ballast Water Treatment Technologies

## Ozonation

### Main parameters

- TRO level downstream
- Ozone concentration at injection point

### Affecting performance

- Temperature
- Ozone concentration at injection point
- Holding time
- Contact time
- DOC, POC, TSS
- Salinity
- Injection pressure

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**Contact Information**

- info@bwm.no

**Ballast Water Treatment – overview of approved and available systems**

**Mouawad Consulting**

**Date:** 2013-11-01
Ballast Water Treatment Systems
# Ballast Water Treatment Systems

(source: www.bwm.no)

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<th>Approval</th>
<th>Admin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfa Laval</td>
<td>PureBallast</td>
<td>Filtration + Advanced Oxidization</td>
<td>Yes</td>
<td>Type Approved</td>
<td>Norway</td>
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<tr>
<td>Alfa Laval</td>
<td>PureBallast 2.0/2.0 Ex</td>
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<td>Norway</td>
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<td>Filtration + UV</td>
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<td>OceanSaver Mk I</td>
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<td>Type Approved</td>
<td>Norway</td>
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<td>Optimarin</td>
<td>Optimarin Ballast System (OBS)</td>
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<td>Headway Marine Technology</td>
<td>OceanGuard BWMS</td>
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<td>Crystal Ballast BWMS</td>
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<td>NK Co., Ltd.</td>
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<td>MMC</td>
<td>MMC BWMS</td>
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<td>No</td>
<td>Type Approved</td>
<td>Norway</td>
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(source: [www.bwm.no](http://www.bwm.no))

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<td>13</td>
<td>Severn Trent De Nora</td>
<td>BalPure BWMS</td>
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<td>Mahle</td>
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<td>Mitsui Engineering and Shipbuilding Co., LTD.</td>
<td>FineBallastOZ</td>
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<td>Hitachi</td>
<td>ClearBallast BWMS</td>
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<td>HHI</td>
<td>EcoBallast</td>
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<td>South Korea</td>
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<td>Techcross</td>
<td>Electro-Cleen System (ECS-A)</td>
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<td>Techcross</td>
<td>Electro-Cleen System (ECS-B)</td>
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<td>21</td>
<td>Panasia Co., Ltd.</td>
<td>GloEn-Patrol</td>
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<td>HHI</td>
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<td>Hyde Marine Inc.</td>
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<td>No</td>
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<td>24</td>
<td>GEA Westfalia Separator Group GmbH</td>
<td>Ballast Master ultraV BWMS</td>
<td>No</td>
<td>Type Approved</td>
<td>Germany</td>
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Ballast Water Treatment – overview of approved and available systems

2013-11-01
## Ballast Water Treatment Systems

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<tbody>
<tr>
<td>25 GEA Westfalia Separator Group GmbH</td>
<td>Ballast Master ecoP BWMS</td>
<td>Filtration + Electrolysis + Chemical Injection</td>
<td>Yes</td>
<td>Basic Approval</td>
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<tr>
<td>26 Shanghai Cyeco Environmental Technology Co. Ltd.</td>
<td>Cyeco BWMS</td>
<td>Filtration + UV + Ultrasound</td>
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<td>China</td>
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<td>27 Kuraray</td>
<td>Microfade BWMS</td>
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<td>Type Approved</td>
<td>Japan</td>
</tr>
<tr>
<td>28 AQUA Eng. Co., Ltd.</td>
<td>AquaStar BWMS</td>
<td>Filtration + Electrolysis</td>
<td>Yes</td>
<td>Type Approved</td>
<td>Korea</td>
</tr>
<tr>
<td>29 Erma First</td>
<td>Erma First BWMS</td>
<td>Hydrocyclone + Electrolysis</td>
<td>Yes</td>
<td>Type Approved</td>
<td>Greece</td>
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<tr>
<td>30 Samsung Heavy Industries</td>
<td>Purimar System</td>
<td>Filtration + Electrolysis</td>
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<td>Type Approved</td>
<td>South Korea</td>
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<tr>
<td>31 Wuxi Brighsky Electronic Co., Ltd</td>
<td>BSKY BWMS</td>
<td>Filtration + UV + Ultrasound</td>
<td>No</td>
<td>Type Approved</td>
<td>China</td>
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<td>32 China Ocean Shipping Company</td>
<td>Blue Ocean Shield BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Type Approved</td>
<td>China</td>
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<tr>
<td>33 21st Century Shipbuilding</td>
<td>ARA BWMS</td>
<td>Filtration + UV + High Energy Plasma</td>
<td>No</td>
<td>Final Approval</td>
<td>South Korea</td>
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<td>34 Siemens</td>
<td>SiCURE BWMS</td>
<td>Filtration + Electrolysis</td>
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<td>Final Approval</td>
<td>Germany</td>
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<tr>
<td>35 Dow Chemicals</td>
<td>Dow-Pinnacle BWMS</td>
<td>Filtration + Ozonation</td>
<td>Yes</td>
<td>Ongoing</td>
<td>Singapore</td>
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<tr>
<td>36 Elite Marine Ballast Water Treatment Corp.</td>
<td>Seascape BWMS</td>
<td>Filtration + UV + Ultrasound</td>
<td>No</td>
<td>Ongoing</td>
<td>Norway</td>
</tr>
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<td>37 Trojan Marinex</td>
<td>Trojan UV BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Ongoing</td>
<td>Norway</td>
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<td>38 Bawat AS</td>
<td>Bawat BWMS</td>
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<td>Ongoing</td>
<td>Denmark</td>
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<td>39 Redox</td>
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<td>OxyClean BWMS</td>
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<td>Smart Ballast BWMS</td>
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<td>43 JFE Engineering Corporation</td>
<td>JFE BallastAce BWMS</td>
<td>Filtration + Chemical Injection</td>
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<td>Japan</td>
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<td>44 NEI</td>
<td>Ventury Oxygen Stripping</td>
<td>De-oxygenation</td>
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<td>Liberia</td>
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<td>45 RWO</td>
<td>CleanBallast BWMS</td>
<td>Filtration + Electrolysis + Electrochlorination</td>
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<td>46 Resource Ballast Technologies (Pty) Ltd.</td>
<td>Resource Ballast Technologies System</td>
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<td>South Africa</td>
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<td>47 Kwang San Co., Ltd.</td>
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<td>South Korea</td>
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<td>48 Envirotech and Consultancy Pte. Ltd.</td>
<td>Blueseas BWMS</td>
<td>Filtration + Electrolysis</td>
<td>Yes</td>
<td>Basic Approval</td>
<td>Singapore</td>
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<tr>
<td>Katayama Chemical, Inc.</td>
<td>SKY-SYSTEM® with Peraclean® Ocean BWMS</td>
<td>Filtration + Chemical Injection</td>
<td>Yes</td>
<td>Basic Approval</td>
<td>Japan</td>
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<td>JFE Engineering Corporation</td>
<td>JFE BallastAce that makes use of NeoChlor Marine® BWMS</td>
<td>Filtration + Chemical Injection</td>
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<td>Envirotech and Consultancy Pte. Ltd.</td>
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<td>Singapore</td>
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<td>Samsung Heavy Industries Co., Ltd.</td>
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<td>Dalian Maritime University</td>
<td>DMU ·OH BWMS</td>
<td>Filtration + Chemical Injection</td>
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<td>China</td>
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<td>Hanla IMS Co., Ltd.</td>
<td>EcoGuardian BWMS</td>
<td>Filtration + Electrolysis</td>
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<td>South Korea</td>
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<td>Korea Top Marine (KT Marine) Co., Ltd.</td>
<td>KTM-BWMS</td>
<td>Electrolysis + Plankill pipe (circular cylinder block)</td>
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<td>South Korea</td>
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<td>Netherlands</td>
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<td>Jiujiang Precision Measuring Technology Research Institute</td>
<td>OceanDoctor BWMS</td>
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<td>Yes</td>
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<td>South Korea</td>
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<tr>
<td>Van Oord B.V.</td>
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<td>Chlorination (Drinking water only)</td>
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<td>Basic Approval</td>
<td>Netherlands</td>
</tr>
<tr>
<td>SUNBO INDUSTRIES Co. Ltd., DSEC Co. Ltd. and the Korean Institute of Machinery &amp; Material (KIMM)</td>
<td>Blue Zone BWMS</td>
<td>Ozonation</td>
<td>Yes</td>
<td>Basic Approval</td>
<td>South Korea</td>
</tr>
<tr>
<td>Wärtsilä</td>
<td>Wärtsilä Aquarius UV BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Type Approved</td>
<td>Netherlands</td>
</tr>
<tr>
<td>Kwang San Co., Ltd.</td>
<td>BioViolet BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Ongoing</td>
<td>South Korea</td>
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<tr>
<td>Bio UV</td>
<td>Bio-Sea BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Ongoing</td>
<td>France</td>
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<tr>
<td>Sumitomo Electric Industries, Ltd.</td>
<td>SEI-BWMS</td>
<td>Filtration + UV</td>
<td>No</td>
<td>Ongoing</td>
<td>Japan</td>
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<tr>
<td>ColdHarbour Marine</td>
<td>ColdHarbour BWMS</td>
<td>Cavitation + De-oxygenation + Ultrasound</td>
<td>No</td>
<td>Ongoing</td>
<td>UK</td>
</tr>
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USCG Type Approval
USCG Type Approval

USCG / ETV tests vs. IMO G8

The UV challenge

When type approval by USCG is expected?