WÄRTSILÄ

AQUARIUS®

Ballast Water Management Systems (BWMS)
content

- Introduction & technology landscape

- The Wärtsilä AQUARIUS® 2-stage BWMS approach
  - Stage 1 – Common filtration approach
  - Stage 2 – Wärtsilä AQUARIUS®UV & AQUARIUS®EC overview
    - Main system features
    - Operational block diagram
    - Modular design and supply
    - Equipment land and sea based testing
    - Common Q&A

- IMO and USCG status and Wärtsilä AQUARIUS® product development

- Shipyard and ship owner/operator considerations

- The Wärtsilä BWMS Partnership Program
ballast water – the challenge

To stop the spread of non-indigenous invasive species via the management/treatment of ship ballast water and sediments

- @7000 species can be carried in a ballast tank at any one time
- @7 billion tonnes of ballast water are discharged each year
- Recognised as a worldwide problem
- One of the greatest threats to the world’s coastal waters
- Accelerating the spread of harmful organisms
- Generally irreversible
technology choice ...

... no one-technology fits all (ship type, size operational profile etc)
Wärtsilä AQUARIUS® BWMS – 2 stage approach

... choice of technology

Wärtsilä **AQUARIUS® UV** - Filter + UV disinfection *(IMO Type Approved)*

Wärtsilä **AQUARIUS® EC** - Filter + Electro-Chlorination (EC) *(IMO FINAL Approval)*

---

**STAGE 1**
- Filtration / separation

**STAGE 2**
- Treatment or conditioning

[Diagram showing stages: Uptake, Ballast Tank, Discharge]
AQUARIUS®

common filtration approach
Common to both Wärtsilä AQUARIUS®UV & Wärtsilä AQUARIUS®EC

General features:

• Screen type filtration method
• Automatic back wash cleaning cycle
• Inherent flexibility to cater for a varying load
• Well proven applications in the marine and offshore sector
• Modular construction for new build and retrofit application
• Low pressure drop (~0.3 Bar)
the Wärtsilä AQUARIUS® filter

- backwashing 40µm screen type filter
- removes 98% of particles greater than 50 micron
- reduces impact of sediment on the ballast tanks
- automatic back wash cleaning cycle
- Low pressure drop (~0.3 Bar)

Filter animation

BW test sample video

Spring operated suction nozzles
AQUARIUS®

two treatment options
Wärtsilä AQUARIUS® – treatment choice

Choice of ballast water treatment technology:

1. **Ultra-violet (UV) treatment (TYPE APPROVED)**
   - Not an active substance approach – no chemicals
   - Treatment on both uptake and discharge
   - Filtration/separation is more critical in UV treatment
   - Need to ensure protection of the UV (lamp mounts, cleaning etc)

2. **Electro-chlorination (EC) treatment (IMO FINAL APPROVED)**
   - Active substance approach
   - Side stream electrolysis for hypochlorite generation
   - Treatment on uptake only
   - Neutralise on discharge (if required)

Both technology options have (explosion proof) **EX options**
AQUARIUS® UV

treatment using Ultra-Violet light
Wärtsilä AQUARIUS® UV – main features

- Medium pressure UV lamp chamber with cross flow lamps
- Designed to maintain dose in challenging conditions
- Wiper system fitted to maintain clean quartz sleeves
- Designed to be corrosion resistant
- Chambers contain 6, 12 or 18 lamps of varying powers
- Single chambers available in 50m³/hr to 1,000m³/hr sizes
- Higher BW treatment volumes using multiple UV chambers
- Fitted in bypass to the main ballast line

Container ised AQ-250-UV system
UV animation
Wärtsilä AQUARIUS®UV – block diagram

- View block diagram in Uptake mode
- View block diagram in Discharge mode
<table>
<thead>
<tr>
<th>AQUARIUS® Module</th>
<th>Filtration Module</th>
<th>UV Treatment Module</th>
<th>UV Power Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (m³/hr)</td>
<td>Dimensions (m)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>W</td>
</tr>
<tr>
<td>AQ-50-UV</td>
<td>0 - 50</td>
<td>2.00</td>
<td>0.75</td>
</tr>
<tr>
<td>AQ-80-UV</td>
<td>50 - 80</td>
<td>2.40</td>
<td>0.75</td>
</tr>
<tr>
<td>AQ-125-UV</td>
<td>80 - 125</td>
<td>2.40</td>
<td>0.80</td>
</tr>
<tr>
<td>AQ-180-UV</td>
<td>125 - 180</td>
<td>2.40</td>
<td>0.80</td>
</tr>
<tr>
<td>AQ-250-UV</td>
<td>180 - 250</td>
<td>2.40</td>
<td>0.80</td>
</tr>
<tr>
<td>AQ-300-UV</td>
<td>250 - 300</td>
<td>2.40</td>
<td>0.80</td>
</tr>
<tr>
<td>AQ-375-UV</td>
<td>300 - 375</td>
<td>2.70</td>
<td>1.10</td>
</tr>
<tr>
<td>AQ-430-UV</td>
<td>375 - 430</td>
<td>2.70</td>
<td>1.10</td>
</tr>
<tr>
<td>AQ-500-UV</td>
<td>430 - 500</td>
<td>3.00</td>
<td>0.90</td>
</tr>
<tr>
<td>AQ-550-UV*</td>
<td>500 - 550</td>
<td>3.00</td>
<td>0.90</td>
</tr>
<tr>
<td>AQ-750-UV*</td>
<td>550 - 750</td>
<td>3.70</td>
<td>1.30</td>
</tr>
<tr>
<td>AQ-850-UV**</td>
<td>750 - 850</td>
<td>3.70</td>
<td>1.30</td>
</tr>
<tr>
<td>AQ-1000-UV**</td>
<td>850 - 1000</td>
<td>3.80</td>
<td>1.30</td>
</tr>
</tbody>
</table>
... flexible arrangement to suit available space
Wärtsilä AQUARIUS®UV – test installations

Land based testing

NIOZ
The Netherlands

Ship based testing

MV TWISTER
Chemgas BV
### Test Cycle Report

**Treatment system:** Harwood Bay Ballast Water Management System, England

**Ship details:** Tugnet (IMO 9507591), UWT 2,000, LOA 100 m.

- **Date and time for ballast water discharge:** 22.11.2011, 10:47 to 12:48
- **Position of ship during ballast water uptake in Port of Kiel:**
  - Distance travelled during ballast water was 0 km.
  - Water depth on 0 m.

**Test Conditions:**
- **Date and time for ballast water discharge:** 22.11.2011, 10:47 to 12:48
- **Water temperature at discharge:** approximately 22 °C

**Weather Conditions:**
- Forecast good.

### Water Quality and Number of Living Organisms in Uplake and Discharge Water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Uplake water</th>
<th>Discharge water</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>-</td>
<td>-</td>
<td>0.0</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/l</td>
<td>8.1</td>
<td>7.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>12.8</td>
<td>12.6</td>
<td>0.2</td>
</tr>
<tr>
<td>Salinity</td>
<td>ppt</td>
<td>30.1</td>
<td>30.3</td>
<td>0.2</td>
</tr>
<tr>
<td>DOC</td>
<td>mg/l</td>
<td>20.7</td>
<td>20.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>19.3</td>
<td>19.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Salinity</td>
<td>ppt</td>
<td>38.5</td>
<td>38.7</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Remarks:**
- All technical requirements, such as minimum water volume of the water to be sampled etc., for a valid test according to IMO guidelines O9 were met.
- Pelagic organisms above 50 μm and organisms below 50 and above 10 μm in minimum dimension are not organisms that cause risk to the marine environment.
- Discharge Certificate will be submitted to IMO, Britain.
- Date and signature of the sampling crew leader: S. Kallisch, 01.11.2011.
What is the warm up time?
System warm up time is 3-5 minutes depending on system size

What is the lamp life?
Lamp life is estimated to be 2,500 hours or 3 years

Is the system flexible on capacity?
Typically flows down to 10% of total rated capacity (TRC)

Flexibility of supply?
System supplied in skid form or as a kit of parts for tight access and/or in retrofit applications

What are the typical maintenance and OPEX costs?
Estimated maintenance man hours and annualised OPEX costs are shown separately
### UV Chamber

<table>
<thead>
<tr>
<th>Timescale</th>
<th>Item</th>
<th>Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly</td>
<td>Wiper / Quartz Seal Service, Air Filters and UV Sensor Calibration</td>
<td>6</td>
</tr>
<tr>
<td>3 Yearly (or 2500 Hours)</td>
<td>UV Lamp Change</td>
<td>5</td>
</tr>
<tr>
<td>5 Yearly (or 5000 Hours)</td>
<td>Quartz Sleeve Change</td>
<td>6</td>
</tr>
</tbody>
</table>

### Filter Unit

<table>
<thead>
<tr>
<th>Timescale</th>
<th>Item</th>
<th>Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly</td>
<td>Annual inspection</td>
<td>2</td>
</tr>
<tr>
<td>3 Yearly</td>
<td>Seals and nozzle change</td>
<td>8</td>
</tr>
<tr>
<td>5 Yearly</td>
<td>Main screen and drive replacement</td>
<td>12</td>
</tr>
</tbody>
</table>
Assumptions

• 1,000m³/hr AQUARIUS®UV BWMS
• OPEX costs averaged over a 5 year period

Annualised OPEX cost estimates

• Filter module £8,000 / year
• UV module £6,660 / year

**TOTAL** £14,670 (US$22,740) / year
AQUARIUS®EC

treatment using Electro-Chlorination
Wärtsilä AQUARIUS®EC – main features

- Disinfection using sodium hypochlorite - treats the ballast water on uptake only
- Sodium hypochlorite produced using side stream electrolysis - low volume fixed rate at 5m³/hr
- Residual chlorine automatically neutralised on discharge
- Automatic control of dosing and neutralisation
- Hydrogen safely removed before water enters the ballast tank
- Efficient up-scaling for the treatment of large flow volumes - 6,000+ m³/hr
- On board sea water feed used when the ship is in low salt water
- Fitted in bypass to the main ballast line
- View block diagram in Uptake mode
- View block diagram in Discharge mode
- View block diagram with fresh water Discharge mode
## Wärtsilä AQUARIUS® EC – Data Sheet

### Single Basket Filter Options

<table>
<thead>
<tr>
<th>AQUARIUS® Module</th>
<th>Filtration Module</th>
<th>EC Treatment Module</th>
<th>EC Power Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity (m³/hr)</td>
<td>Dimensions (m)</td>
<td>Dry Weight (kg)</td>
</tr>
<tr>
<td>AQ-125-EC</td>
<td>80-125</td>
<td>2.40 0.80 1.55</td>
<td>760 150</td>
</tr>
<tr>
<td>AQ-250-EC</td>
<td>180-250</td>
<td>2.40 0.80 1.60</td>
<td>1050 200</td>
</tr>
<tr>
<td>AQ-300-EC</td>
<td>250-300</td>
<td>2.40 0.80 1.60</td>
<td>1050 200</td>
</tr>
<tr>
<td>AQ-375-EC</td>
<td>300-375</td>
<td>2.70 1.10 2.00</td>
<td>1500 250</td>
</tr>
<tr>
<td>AQ-430-EC</td>
<td>375-430</td>
<td>2.70 1.10 2.00</td>
<td>1500 250</td>
</tr>
<tr>
<td>AQ-500-EC</td>
<td>430-500</td>
<td>3.00 0.90 2.00</td>
<td>1700 300</td>
</tr>
<tr>
<td>AQ-550-EC</td>
<td>500-550</td>
<td>3.00 0.90 2.00</td>
<td>1700 300</td>
</tr>
<tr>
<td>AQ-750-EC</td>
<td>550-750</td>
<td>3.70 1.30 2.50</td>
<td>3100 350</td>
</tr>
<tr>
<td>AQ-850-EC</td>
<td>750-850</td>
<td>3.70 1.30 2.50</td>
<td>3100 350</td>
</tr>
<tr>
<td>AQ-1000-EC</td>
<td>850-1000</td>
<td>3.80 1.30 2.50</td>
<td>3200 350</td>
</tr>
<tr>
<td>AQ-1200-EC</td>
<td>1000-1200</td>
<td>3.90 1.30 2.70</td>
<td>3550 400</td>
</tr>
</tbody>
</table>

Multi basket filter configurations will extend range to 1,500 / 2,000 / 2,400 / 3,000 / 3,300 m³/hr.
Wärtsilä AQUARIUS®EC – modular design

Hypochlorite Generation Skid

Hypochlorite Dosing Skid

... flexible arrangement to suit available space
Wärtsilä AQUARIUS®EC – test installations

**Land based testing**

NIOZ
The Netherlands

**Ship based testing**

ANVIL POINT
Foreland Shipping

NIOZ
The Netherlands

Land based testing

Ship based testing
Wärtsilä AQUARIUS®EC – test results

Land based testing COMPLETE

<table>
<thead>
<tr>
<th>EC Series No.</th>
<th>Salinity</th>
<th>Zooplankton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Brackish</th>
<th>Ave</th>
<th>99.817%</th>
<th>Ave</th>
<th>99.998%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.3</td>
<td></td>
<td></td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.7</td>
<td></td>
<td>99.969%</td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td></td>
<td>99.997%</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>3.3</td>
<td></td>
<td>99.995%</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>9.7</td>
<td></td>
<td>99.985%</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>6</td>
<td>4.7</td>
<td></td>
<td>99.993%</td>
<td></td>
<td>0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sea Water</th>
<th>Ave</th>
<th>99.996%</th>
<th>Ave</th>
<th>100.000%</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>2.3</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>0.7</td>
<td></td>
<td>99.998%</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>9</td>
<td>0.0</td>
<td></td>
<td>100.000%</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>10</td>
<td>1.3</td>
<td></td>
<td>99.994%</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td></td>
<td>99.998%</td>
<td></td>
<td>0.0</td>
</tr>
</tbody>
</table>

Ship based testing COMPLETE

BASIC Approval October 2012

FINAL Approval May 2013

Type Approval October 2013
What is sodium hypochlorite dose?
The dose is 10ppm

What is the electrolysis cell life?
Cells should last the lifetime of the system (clean every 2 years)

To what level is the discharge neutralised if needed?
The discharge is neutralised to 0.1ppm (IMO limit is 0.2ppm) using Sodium Bisulphite

Is there a residual dose left in the tanks?
During testing the residual TRO after 5 days was typically 3-4ppm

Does the system produce hydrogen?
All EC based systems produce hydrogen, AQUARIUS®EC includes automatic detection, dilution and ventilation to atmosphere before water enters the ballast tank

Does the EC system have any detrimental affect on tank materials or coatings?
No – but more detail is shown separately

What are the typical maintenance and OPEX costs?
Estimated maintenance man hours and annualised OPEX costs are shown separately
### EC Modules

<table>
<thead>
<tr>
<th>Timescale</th>
<th>Item</th>
<th>Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Yearly (or 2500 Hours)</td>
<td>Pump and Blower Maintenance</td>
<td>5</td>
</tr>
</tbody>
</table>

### Filter Unit

<table>
<thead>
<tr>
<th>Timescale</th>
<th>Item</th>
<th>Man Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yearly</td>
<td>Annual inspection</td>
<td>2</td>
</tr>
<tr>
<td>3 Yearly</td>
<td>Seals and nozzle change</td>
<td>8</td>
</tr>
<tr>
<td>5 Yearly</td>
<td>Main screen and drive replacement</td>
<td>12</td>
</tr>
</tbody>
</table>
Basic assumptions

- 1,000m³/hr AQUARIUS®EC BWMS
- OPEX costs averaged over a 5 year period

Annualised OPEX cost estimates

- Filter module £8,000 / year
- EC module £400 /year
  TOTAL £8,400 / year
  $13,000 / year

Consumables

**Sodium Bisulfite**

- 40% concentration
- Discharge after 5 days TRO=2ppm)
- 7.13 lit/1000m³
- @£0.7/lit (US$ 1.09/lit)
  TOTAL US$ 7.74 / 1000m³

**TRO Sensor Reagents**

  TOTAL $3,900 / year
AQUARIUS® EC

Hypochlorite disinfection
Chlorine breakpoint

Total Chlorine added = Chlorine demand of the water

“breakpoint”

Chlorine added above the breakpoint provides disinfection
BWMS chlorine design dose (N ppm)

<table>
<thead>
<tr>
<th>N ppm (Total Residual Oxidant, TRO)</th>
<th>&gt; N ppm</th>
<th>Variable (Water Quality Dependent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine Design Dose (TRO)</td>
<td>Total Chlorine added</td>
<td>Chlorine demand of the water</td>
</tr>
<tr>
<td>The amount of Chlorine required to ensure effective disinfection to IMO D2 &amp; USCG Standard</td>
<td>Generated by BWMS electrolysis – a fundamental system design parameter</td>
<td>Inorganic dissolved chemicals (fast consumers of chlorine) Organic matter (dissolved carbon, zoo/phytoplankton)</td>
</tr>
</tbody>
</table>
## Chlorine consumption analysis

<table>
<thead>
<tr>
<th>Added Chlorine (mg/L)</th>
<th>TRO after 5mins</th>
<th>TRO after 60mins</th>
<th>zoo-plankton (n/m³)</th>
<th>phyto-plankton (cell/ml)</th>
<th>TRO after 5 days</th>
<th>zoo-plankton (n/m³)</th>
<th>phyto-plankton (cell/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
<td>32500</td>
<td>2154</td>
<td>-</td>
<td>6100</td>
<td>2854</td>
</tr>
<tr>
<td>1</td>
<td>0.57</td>
<td>26700</td>
<td>905</td>
<td>0.12</td>
<td>3533</td>
<td>226</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.59</td>
<td>11300</td>
<td>&lt;5</td>
<td>0.13</td>
<td>2700</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>0.86</td>
<td>14050</td>
<td>10.6</td>
<td>0.14</td>
<td>2550</td>
<td>20.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.76</td>
<td>7950</td>
<td>&lt;5</td>
<td>0.32</td>
<td>950</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.72</td>
<td>10900</td>
<td>&lt;5</td>
<td>0.17</td>
<td>825</td>
<td>&lt;5</td>
<td></td>
</tr>
</tbody>
</table>

IMO D2 Requirement - <10 <10

Chlorine demand can quickly consume added chlorine. Levels of added chlorine required must be > 5 ppm.

Ref – Laboratory testing conducted at IMARES, The Netherlands
### Chlorine consumption analysis

<table>
<thead>
<tr>
<th>Design Dose (TRO) (mg/L)</th>
<th>Total Added Chlorine (mg/L)</th>
<th>TRO after 2 hours</th>
<th>TRO after 4 hours</th>
<th>zoo-plankton (n/m3)</th>
<th>phyto-plankton (cell/ml)</th>
<th>TRO after 5 days</th>
<th>zoo-plankton (n/m3)</th>
<th>phyto-plankton (cell/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>3350</td>
<td>3404</td>
<td>-</td>
<td>-</td>
<td>1150</td>
</tr>
<tr>
<td>1</td>
<td>15.2</td>
<td>2.76</td>
<td>1.47</td>
<td>1205</td>
<td>&lt;5</td>
<td>0.24</td>
<td>2%</td>
<td>44</td>
</tr>
<tr>
<td>2.5</td>
<td>16.7</td>
<td>4.41</td>
<td>2.52</td>
<td>940</td>
<td>&lt;5</td>
<td>0.28</td>
<td>2%</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>19.2</td>
<td>6.1</td>
<td>4.25</td>
<td>300</td>
<td>&lt;5</td>
<td>0.22</td>
<td>1%</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>24.2</td>
<td>10.5</td>
<td>8.36</td>
<td>165</td>
<td>&lt;5</td>
<td>0.5</td>
<td>2%</td>
<td>1</td>
</tr>
</tbody>
</table>

**IMO D2 Requirement**

<table>
<thead>
<tr>
<th>Total Added Chlorine (mg/L)</th>
<th>TRO after 2 hours</th>
<th>TRO after 4 hours</th>
<th>zoo-plankton (n/m3)</th>
<th>phyto-plankton (cell/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18%</td>
<td>1.47</td>
<td>0.28</td>
<td>44</td>
<td>23</td>
</tr>
<tr>
<td>32%</td>
<td>6.1</td>
<td>0.22</td>
<td>4</td>
<td>&lt;5</td>
</tr>
<tr>
<td>43%</td>
<td>10.5</td>
<td>0.5</td>
<td>1</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>

Ref – Laboratory testing conducted at IMARES, The Netherlands

**To ensure compliance with the IMO D2 standard, the Design Dose (TRO) level must be > 5ppm**

D2 compliant
TRO Concentration as a function of Time

AQUARIUS-EC dose (TRO) = 10ppm

TRO consumption 5.5ppm over 5 days

Ship Based Testing

Land Based Testing

Ref – Land Based tests conducted at NIOZ, The Netherlands, Sea based testing on board ‘ANVIL POINT’
Wärtsilä AQUARIUS® EC - dose control

- Hypochlorite supply from the ‘buffer’ tank
- Design Dose = 10ppm
- Colorimetric based sensors used to measure TRO (Chlorine) at each sample point
- Automatic dose control using TRO sensors upstream & downstream of the static mixer

Ref – Sea based testing on board ‘ANVIL POINT’
Wärtsilä AQUARIUS® EC - dose control

- Dose control during ballast water uptake
- Design Dose = 10 ppm
- Graph showing the consistent dose control during filter backwashing
- In the water conditions experienced during sea trials, a backwash cycle occurred every 30-35 minutes

Ref – Sea based testing on board ‘ANVIL POINT’
AQUARIUS®EC

neutralisation

(submitted as part of the IMO FINAL Approval)
• TRO design dose 10ppm at point of mixing
• Decay of TRO in the ballast tank as disinfection continues
• Automatic neutralisation with Sodium Bisulphite, if required
• Sodium Bisulphite is consumed at a rate of @7 litres/1000m³ (nominal rate)
• MARPOL compliant discharge < 0.2mg/L

Ref – Sea based testing on board ‘ANVIL POINT’
AQUARIUS®EC

corrosion testing

(submitted as part of the IMO FINAL Approval)
### Laboratory test outline

- **Laboratory tests using:**
  - Reference (untreated) sea water
  - AQUARIUS-EC (treated) sea water

- **Raw materials considered include:**
  - Uncoated carbon steel
  - 316 Stainless Steel
  - Rubber & Viton

- **Carbon steel coated with:**
  - Sigmaprime 700
  - Intershield 300

Ref – Laboratory testing conducted at EXOVA, UK
Laboratory testing – corrosion tests (with coatings)

- Test duration 6 months
- Two PSPC approved epoxy coatings systems were used
- Coatings supplied by two major paint suppliers
  - PPG
  - International Paints
- Replicate scribed & unscribed samples were used

Three exposure zones were examined to simulate real ballast tank conditions

- Zone C (deck head)
- Zone B (splash)
- Zone A (submerged)

Ref – Laboratory testing conducted at EXOVA, UK
Uncoated carbon steel

- Material loss was observed to be higher in the case of untreated water rather than in samples exposed to treated water.
- In quantitative terms after a 6 month exposure, carbon steel in untreated water averaged a weight loss of 3.21% whilst samples exposed to treated water averaged weight loss of 2.58%.

Uncoated 316 stainless steel

- Test results indicate that when exposed to treated and untreated water weight loss was the same @0.07%.

Rubber and Viton tests

- No effect. To the contrary the sealing material Viton indicates an average weight gain of 0.86% in untreated seawater and 0.81% in treated water.

Ref – Laboratory testing conducted at EXOVA, UK
Laboratory testing – coating results

- None of the coated panels in untreated or treated water showed any visual signs of corrosion after testing
- Blistering, rusting, cracking and chalking evaluations were negative on all coated panels
- The corrosion assessment (pick-back/creep) showed little or no difference between panels in treated or untreated water
- Coating adhesion results were near identical in all cases examined

Conclusion

In all cases tested PSPC requirements were met in full and no evidence of adverse influence on the coatings was found over the 6 month test period

Ref – Laboratory testing conducted at EXOVA, UK
AQUARIUS®
installation features
• Both systems are installed in bypass to the main ballast line
• Flow is diverted from the ballast main to the system, treated and returned, a bypass valve is fitted between these points
• The new valves installed to achieve this are additional valves within the vessel control system
• An overboard is required for filter back flush
• Main equipment does not need to be in the location of the ballast pumps or ballast main
• A remote panel is normally located in the control room for basic observation and control purposes – options available
• If required the modules can be supplied as equipment only for mounting during installation in tight spaces (retrofit)
Wärtsilä AQUARIUS® – installation examples

AQUARIUS® UV

AQUARIUS® EC
AQUARIUS®
approval status
regulation update & approval update

- IMO Ballast Water Convention
- USCG Ballast Water Regulations
- Status of the Wärtsilä AQUARIUS® development activity
regulation update

Global

<table>
<thead>
<tr>
<th>Countries</th>
<th>World GRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>30.38%</td>
</tr>
<tr>
<td>30</td>
<td>35%</td>
</tr>
</tbody>
</table>

All ships > 400GRT trading internationally

US (Local)

2013 VGP in place
in force from Dec 2013

All ships > 300GRT operating in US waters

United States Coast Guard
U.S. Department of Homeland Security
### IMO phased implementation

<table>
<thead>
<tr>
<th>Ships constructed during or after 2009</th>
<th>Year of construction</th>
<th>Ballast water capacity (m3)</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>During or after 2009</td>
<td>&lt; 5.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009 but before 2012</td>
<td>≥ 5.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During or after 2012</td>
<td>≥ 5.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before 2009</td>
<td>1.500 – 5.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before 2009</td>
<td>&lt; 1.500 or &gt; 5.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ships constructed before 2009**

- Before 2009: 1.500 – 5.000
- Before 2009: < 1.500 or > 5.000

**MEPC-65 working group proposal to change implementation dates to align with ship IOPP survey**
USCG phased implementation

Installed BWMS to be USCG type approval no later than 5 years from ship compliance date

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Date Constructed</th>
<th>Ballast Tank capacity</th>
<th>Compliance Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing vessels</td>
<td>Before 1&lt;sup&gt;st&lt;/sup&gt; Dec 2013</td>
<td>&lt;1,500m&lt;sup&gt;3&lt;/sup&gt; or &gt;5,000m&lt;sup&gt;3&lt;/sup&gt;</td>
<td>First scheduled docking after 1&lt;sup&gt;st&lt;/sup&gt; Jan 2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,500m&lt;sup&gt;3&lt;/sup&gt; to 5,000m&lt;sup&gt;3&lt;/sup&gt;</td>
<td>First scheduled docking after 1&lt;sup&gt;st&lt;/sup&gt; Jan 2014</td>
</tr>
<tr>
<td>New vessels</td>
<td>On or after 1&lt;sup&gt;st&lt;/sup&gt; Dec 2013</td>
<td></td>
<td>On delivery</td>
</tr>
</tbody>
</table>
AQUARIUS®UV

- Flag Administration - Holland (ILT)
- Classification Society - Lloyds Register
- Land based testing complete (NIOZ Holland)
- Ship board testing complete (Dutch Owner)
- **IMO Type Approval - 20th December 2012**
- EX version ready by October 2013

AQUARIUS®EC

- Flag Administration - Holland (ILT)
- Classification Society - Lloyds Register
- Land based testing complete (NIOZ Holland)
- Ship board testing complete (UK Owner)
- **BASIC IMO Approval at MEPC-64 (Oct ’12)**
- **FINAL IMO Approval at MEPC-65 (May ‘13)**
- IMO Type Approval target date October 2013
- EX version ready by December 2013
USCG development plan

**AQUARIUS® UV**

- **IMO Type Approval**
- **AMS status (Pending)**
- **USCG Type Approval**

- **Dec 2012**

**AQUARIUS® EC**

- **IMO Type Approval (October 2013)**
- **AMS status**
- **USCG Type Approval**

- **2012**
- **2013**
- **2014**
- **2015**
Next steps

BWMS selection?
Installation planning?
The Wärtsilä Partnership Program
# BWMS selection considerations

## General
- Ship type
- Ballast pump capacity
- Space required (foot print and volume)
- Flexibility of location of system components
- Integration with existing power and control systems
- CAPEX

## Ship Specific
- Gravity ballasting operations
- Tank stripping
- Hazardous area installation
- Trading pattern
- Short or long voyages
- Fresh water
- Cold water operation

## Installation
- Flexible arrangement
- Appropriate component and material choice
- Ease of installation
- Efficient use of space and integration
- Good planning and equipment logistics
- Meet Class and Flag State requirements
- Minimum impact on ship operations and trading

## Resource
- Health and safety
- Additional crew workload
- Availability of consumables
- Availability of spares and support
- Crew training
- OPEX
- System availability/ lead-time
- Design resources
- Electrical/Mechanical installers
- Dry docks
- Surveyors
Installation planning

Plan now

• review fleet requirements
• evaluate technology choices
• develop your specifications
• discuss your requirements with credible suppliers

Formulate your new build or retrofit strategy

• evaluate technical resource requirements
• engineering and project management
• Classification society plan approval
• equipment availability and logistics
• plan installation programme and budget
Wärtsilä BWMS Partnership Program

adding value to the customers business

- **technology choice** to suit the ship type and operational profile
- **modular design** for ease of new build or retrofit installation
- **flexible turnkey** installation capability
- **strong brand** & credible supplier to the marine & offshore sector
- **proven global life cycle support** capability

---

**Wärtsilä BWMS Partnership Program**

- Ballast management planning
- Fleet evaluation
- Confirmation of regulatory requirements
- Ballast water management systems technology choice
- Value proposition
- Timeline verification
- Partnership

- Information collection: ship details and operating profile
- Price indications (previous projects)

- Ship survey
- Equipment configuration
- Concept / GA Interfacing
- Feasibility report
- Capex / opex estimates
- Project outline

- Basic engineering
- Preliminary approvals
- Final project plan
- Sub-contractors selection
- Firm offer and contract for turnkey delivery

- Completion of basic engineering
- Detailed engineering
- Procurement
- Drawings approvals from class
- Installation preparations

- Equipment delivery for prefabrication / installation
- Prefabrication
- Installation works and site management

- Tests
- Approvals from Flag/Class
- Commissioning
- Crew trainings
- Hand over

- Technical support
- Spares/service
- Maintenance
- Fleet support contract
- Compliance verification
- Equipment upgrade (future proofing)
- Global presence

---

**LIFECYCLE SUPPORT**

**PLANNING**

**SUPPLY & INSTALLATION (RETROFIT)**
Thank you - any questions?