BALLAST WATER TREATMENT
PRESERVING & PROTECTING OUR WATERWAYS

Ballast water is full of aquatic species, including bacteria, small invertebrates, microbes, eggs, cysts and larvae of various species. Water taken on in one ecological zone and released into another can result in the introduction and spread of aquatic invasive and nuisance species. This is a serious threat to our environment.

The safe and effective treatment of ballast water is of utmost importance. And, due to the implementation of the International Maritime Organization (IMO) Ballast Water Management (BWM) Convention, U.S. Coast Guard (USCG) and United States Environmental Protection Agency (USEPA) regulations, it is now an absolute necessity.

Trojan Marinex is here to help.
Our focus is solely on the marine industry and providing ballast water treatment solutions. However, we are part of a larger organization: the Trojan Technologies group of companies. Collectively, this group is dedicated to providing water confidence and has played an important role in the development of many of today’s water treatment innovations. Many of the products developed by these companies are installed in large applications around the world, and are relied upon to effectively treat the most challenging of waters.

Trojan Technologies is part of Danaher Corporation’s (DHR : NYSE) environmental platform. Danaher is a Fortune 200, global science and technology leader, with over $18 billion in revenue in 2012. Their commitment to innovation ensures unparalleled product development.

Direct access to nearly 40 years of industry-defining water treatment expertise, in combination with steadfast backing, has enabled us to create a suite of ballast water treatment (BWT) systems unlike any other.

Our systems are purpose-built for the marine environment, and provide filtration + ultraviolet (UV) disinfection in a single, compact unit.
WE’LL HELP YOU UNDERSTAND THE REGULATIONS

Since the 1970s, Trojan Technologies companies have been working closely with regulatory agencies around the world. Throughout this time they’ve helped shape regulations and establish customer compliance in a wide array of water treatment applications. We’re committed to doing the same for you, with respect to the ever-changing ballast water treatment regulations. We’ll help you fully understand them and make sure you achieve compliance. We’re in continual collaboration with the governing bodies – including the USEPA, IMO and USCG – as they continue to release and revise their rules and regulations.

Let’s take a closer look.

**U.S. BALLAST WATER REGULATIONS**

Vessels sailing in U.S. waters will be required to adhere with USCG ballast water discharge standards and the USEPA Vessel General Permit (VGP), in addition to State ballast water regulations. Here are five important details to remember regarding the U.S. regulations:

1. The USCG’s final rule establishes a ballast water discharge standard which is the same as that adopted by the IMO in 2004. In addition, the USEPA 2013 Vessel General Permit has adopted numeric limitations within the permit that also align with the USCG rule.

2. The USCG final rule will affect all vessels – U.S. and foreign – that operate in U.S. waters, are bound for ports or places in the U.S., and are equipped with ballast tanks. These vessels are required to install and operate a USCG Type Approved treatment system before discharging into U.S. waters.

3. The USCG Type Approval process is more stringent and rigorous than the IMO process. As a result, many existing IMO Type Approved systems may not meet USCG requirements, and will require retesting or redesign.

4. The USCG Type Approval process is still under development. To facilitate compliance, USCG has created an Alternative Management System (AMS) process whereby foreign Type Approved systems may be used on a vessel for up to five years after the vessel is required to comply with US ballast water discharge standards.

5. The AMS determination is intended to be an interim measure to allow the treatment system manufacturer sufficient time to obtain USCG Type Approval. After the five year period, the vessel owner must ensure that the system they have on board is USCG Type Approved. AMS determinations provide no guarantee to the owner that the system will meet USCG Type Approval requirements.

**IMC Ballast Water Management Convention compliance timelines.**

<table>
<thead>
<tr>
<th>VESSEL’S BALLAST WATER CAPACITY</th>
<th>DATE CONSTRUCTED</th>
<th>VESSEL’S COMPLIANCE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NEW VESSELS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>On or after December 1, 2013</td>
<td>On delivery</td>
</tr>
<tr>
<td>&gt; 1500 m³</td>
<td>Before December 1, 2013</td>
<td>First scheduled drydocking after January 1, 2016</td>
</tr>
<tr>
<td>1500 – 5000 m³</td>
<td>Before December 1, 2013</td>
<td>First scheduled drydocking after January 1, 2014</td>
</tr>
<tr>
<td>&lt; 5000 m³</td>
<td>Before December 1, 2013</td>
<td>First scheduled drydocking after January 1, 2016</td>
</tr>
<tr>
<td><strong>EXISTING VESSELS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre 2009 **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1500 - 5000</td>
<td>D1 or D2</td>
<td>D2*</td>
</tr>
<tr>
<td>&lt; 1500</td>
<td>D1 or D2</td>
<td>D2*</td>
</tr>
<tr>
<td>&gt; 5000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
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</tr>
<tr>
<td>&lt; 5000</td>
<td>D2</td>
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Prior to entering the ballast water treatment market, we spent the better part of a decade researching, developing, creating and recreating. During this time we dissected oxidizing and non-oxidizing methods, identifying the various benefits and downfalls of each.

We began focusing on filtration + UV because these technologies are:

- Inherently safe and simple to operate
- Do not require chemicals
- Do not form any carcinogenic disinfection by-products
- Not impacted by salinity, temperature, pH or organic loading

**A CONVENTIONAL DESIGN JUST WASN’T AN OPTION**

We found that by simply coupling existing land-based technologies, several adverse effects can occur.

These include large footprint, low efficiency, filter clogging and increased pressure drop.

To establish effective applicability on all vessels and overcome the shortcomings of coupling existing technologies, it became quite apparent that an "off-the-shelf" solution was not a viable option. For us, purpose-built integration (filtration + UV disinfection within one compact unit) was the optimal solution.

SYNERGISTIC EFFECTS ARE CREATED BY INTEGRATING FILTRATION AND UV DISINFECTIO

By combining the two treatment technologies into a single unit, we eliminate the need for additional connecting pipe, pipe elbows and valving connections.
Poorly designed filters (derived from “off-the-shelf”, land-based technology) can result in several issues, including reduced flow rate capacity, clogging, flow disruption, increased power draw and corrosion. These issues negatively affect your ability to trade, and that’s why solving the problems associated with filtration was vital.

INTUITIVE APPROACH TO INNOVATION

We are committed to revolutionizing filtration, and invested significantly in research, design and development. We spent a number of years bench- and full-scale testing a multitude of “off-the-shelf” options, identifying the specific impacts (positive and negative) each had on system performance, operation and reliability.

Understanding every aspect – including construction, types, weave patterns and sizing – was absolutely essential. We rigorously tested numerous filter media and constructions, including wedge wire and an extensive array of mesh options.

To date, we’ve conducted over 300 tests across four independent, land-based test facilities and one shipboard test facility. In our opinion, this process – though arduous and humbling – was an absolute necessity for three reasons. It allowed us to:

1. Fully understand the capacities and limitations of existing filters
2. Conduct in-depth research of filter operability
3. Avoid having to subject our customers to beta technology

WE LEARNED A LOT ALONG THE WAY

Here are a few key findings we think you’ll be interested in. They were uncovered during our robust testing protocol, and aided in the development of our revolutionary filter.

• There is no universal or standard method for rating filter media.

Independent testing indicated effective pore sizes that were, in most cases, very different than the manufacturers’ ratings. Understanding the absolute removal rate of the filter is extremely important, especially in difficult conditions where the system is treating organisms that are vastly different than those tested for during Type Approval.

• Performance cannot be examined in isolation; operability must be examined at the same time.

Performance and operability of the filter are often confused to be the same. Larger pore sizes will lead to longer run times (the period of time between backwash sequences), but can negatively impact filtration efficacy and, ultimately, compliance. Smaller pore sizes can provide excellent removal rates, but may have shorter run times and are more susceptible to clogging. Finding the ideal balance is integral.

• Design focus must be placed on optimizing the efficiency of the filter backwash process.

Many filter designs are inadequate and don’t work in poor water qualities or extreme conditions. Minimizing the amount of water used during backwash sequences is essential, and a larger waste stream drain pipe diameter has positive effects on efficiency.

• Many conventional filters clog and have short run times.

When the surface area is increased, clogging is minimized and run times are lengthened. The filter operates at a lower flux rate (i.e., flow per square inch of media). This lessens filter strain and prevents contorting organisms from squeezing through.

• Even the smallest imperfection or hole will allow organisms to pass through and jeopardize treatment.

By testing in the harshest of conditions, we witnessed many filters stretching, tearing and failing. This confirmed the importance of internal and external structure, sourcing premium material, and ensuring meticulous construction.

Performance integration provides filter redundancy.

Many systems on the market today typically rely on one filter. If those filters were to fail or have issues, ballasting would cease and penalties may be incurred.

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OUR FILTER IS SPECIFICALLY ENGINEERED FOR BWT

Increased Number of Filter Elements

Larger Filter Element

Increased surface area = reduced flux rate and reduced flow restriction.
CUSTOMIZATION WAS THE ONLY SOLUTION

By identifying the inadequacies of “off-the-shelf” filters, while refining specific key features, we proceeded to custom-design and construct our own filtration system – one that would work in unison our TrojanUV Solo Lamp™ disinfection technology. It provides the ideal balance of high performance and reliable run times.

FEATURES

- Larger filter surface area (compared to the industry average)
- 32 micron filter elements, designed specifically for ballast water treatment
- Automatic backwash

BENEFITS

- Continuous operation at required flow rate
- Reduced risk of complete filter blockage
- Less strain on filter
- Contorting organisms are unable to squeeze through

- Consistently high removal rates
- Corrosion-resistant
- Long lifespan
- Easy maintenance

- Less water wasted during backwash
- Optimal cleaning without overstressing filter element
- Prevention of backwash water blockage
- Reduces need to upgrade or install new ballast water pumps
- Senses cleanliness of each filter element and adjusts backpressure accordingly
UV light is a form of light that is invisible to the human eye. Its wavelengths are shorter than visible light but longer than X-rays. A unique characteristic of UV light is that a specific range of its wavelengths, those between 200 and 300 nanometres (billionths of a meter), are germicidal meaning they are capable of neutralizing and inactivating microorganisms.

Since 1977, several Trojan Technologies companies have been developing UV disinfection systems for the toughest of water qualities, including primary treated wastewater. Drawing on that deep-rooted expertise and innovation, the UV disinfection technology incorporated into our ballast water treatment systems truly is second to none.

SOLO LAMP TECHNOLOGY
Low-pressure lamps offer high efficiency and long lamp life. Medium-pressure lamps have higher UV output. The TrojanUV Solo Lamp combines the best features of both. This technology is proprietary, and has over six years of development, lab and field testing behind it.

Features and benefits include:

- High UV output without compromising electrical efficiency or footprint
- Up to ½ the power draw of other UV systems
- Long lamp life
- Robust disinfection throughout low water qualities and cold water temperatures
- Lower power draw in low salinity waters than electrochlorination systems
- Vibration tested for operation in the marine environment

AUTOMATIC LAMP SLEEVE CLEANING
UV lamps are housed within quartz sleeves. Over time, without proper cleaning, sleeves can become fouled. Our automatic, chemical-free cleaning system removes fouling without disrupting operation or disinfection.

UV CHAMBER & LSPACING
Many believe that systems employing UV disinfection will not work in poor water qualities. This is false. In fact, out of all of the ballast water treatment methods available today, filtration + UV is one of the least impacted by varying and poor water qualities because they are physical treatment processes. In contrast, chemical systems – such as electrochlorination (EC) – are often more susceptible to (and negatively impacted by) pH, temperature, salinity, organic loading and turbidity.

A seamlessly engineered UV chamber design and efficient lamp spacing is imperative. That’s why we utilized advanced Computational Fluid Dynamic (CFD) modeling, along with robust land-based and shipboard testing.

We’ve harnessed the true power of each Solo Lamp to ensure maximum disinfection performance. So no matter where in the world vessels sail – be it the clear waters of the Caribbean or the murky Yangtze River – our UV disinfection will perform both effectively and efficiently.

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Regardless of the ballast water capacity or vessel size – from offshore service vessels right through to very large crude carriers – we have the solution.

Our product suite includes a full range of systems that are able to treat any flow rate throughout all water qualities.

For operational flexibility, redundancy or higher flow rates, units can be installed in parallel without compromising efficacy. They can also be installed either vertically or horizontally. And for those vessels requiring explosion-proof systems, Ex versions of each are available.

Here’s an example installation of two Trojan Marinex BWT 500 units, in parallel, treating 1,000 m$^3$/h.

<table>
<thead>
<tr>
<th>FLOW RATE (m$^3$/h)</th>
<th>L x W x H (m)</th>
<th>LAMP POWER (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>1.1 x 0.7 x 1.9</td>
<td>7</td>
</tr>
<tr>
<td>250</td>
<td>1.3 x 1.0 x 2.0</td>
<td>12</td>
</tr>
<tr>
<td>500</td>
<td>1.4 x 1.1 x 2.0</td>
<td>24</td>
</tr>
<tr>
<td>750</td>
<td>1.8 x 1.6 x 2.1</td>
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</tr>
<tr>
<td>1000</td>
<td>1.9 x 1.7 x 2.1</td>
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</tr>
<tr>
<td>1250</td>
<td>2.4 x 1.9 x 2.2</td>
<td>55</td>
</tr>
<tr>
<td>1500</td>
<td>2.4 x 2.3 x 2.3</td>
<td>62</td>
</tr>
</tbody>
</table>
INTEGRATED UNIT: By combining the two treatment technologies into a single unit, we eliminate the need for additional connecting pipe, pipe elbows and valving connections. The end result is a system with a low power draw, small footprint and low backwash pressure requirements.

FILTER: The first treatment stage is filtration. This is when larger organisms and particles are removed. The filter is equipped with an automatic backwash. This helps reduce pressure loss and maximize the UV disinfection stage of the treatment. Filtration only occurs during ballasting (it’s automatically bypassed during deballasting).

POWER DISTRIBUTION CABINET: The main system power, fuses and breakers are all housed here.

CONTROL CABINET: Inside this cabinet are the electronic components that control and monitor the entire treatment system. It’s equipped with a touchscreen Human Machine Interface (HMI) panel which makes system monitoring and status checks quick and easy.

LAMP DRIVER CABINET: Built and certified to withstand harsh marine environments, this cabinet houses the UV lamp drivers and power disconnect switch. Lamp drivers are highly efficient and generate very little waste heat, and use a state-of-the-art digital signal processor to provide advanced diagnostic capabilities. Both air and water cooling options are available.

VORTEX COOLER: Cabinet contents are isolated from humid environment – this feature utilizes compressed air to cool the cabinet, protect lamp drivers and stabilize cabinet temperature. If air cooling is not an option, then water cooling is available.

HYDRAULIC CABINET: This houses the power pack and controls used to drive the lamp sleeve cleaning system.

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INLET/OUTLET FLANGES: Water passes through these for treatment during ballasting and deballasting. Each flange is removable, making installation and retrofitting even easier.

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TROJANUV SOLO LAMP TECHNOLOGY: The second treatment stage is UV disinfection. As the water flows through the array of TrojanUV Solo Lamps, microorganisms in it are inactivated. During deballasting, water bypasses filtration and is again directed through the UV chamber for disinfection.

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All Trojan Marinex BWT systems will be IMO Type Approved in accordance with G8 protocol and the BWM Convention. However, Type Approval is simply our minimum standard. Our ultimate goal is to make sure that every vessel using a Trojan Marinex BWT system passes Port State Control testing each and every time.

Vessels discharging into U.S. waters will be required to install and operate a USCG Type Approved treatment system. While the USCG Type Approval process is still under development, we are taking steps now to ensure that our system will meet these future requirements. A key step in this process is conducting land-based biological efficacy testing according to the Environmental Technology Verification (ETV) protocol.

Filtration is the critical first step in organism removal. Units are equipped with a custom-designed filter. It consistently removes larger organisms (in accordance with discharge standards) while simultaneously removing sediments in the water. The automatic backwash thoroughly cleans each filter element, ensuring relentless treatment and longer run times.

Our compact technology integration is unique. Others keep their treatment methods separate, which increases footprint and piping, and can make for cumbersome retrofitting. All active components in our units are fitted within the same housing, and no extra pipes or fixtures are needed. Also, dry dock installation is not always necessary; installation during voyage is possible.

Filter redundancy = minimized risk.

Conventional Design
(one filter = 1,000 m³/h filtration capacity)

Our Design
(two Trojan Marinex™ BWT 500 units = 1,000 m³/h filtration capacity)
COMPACT FOOTPRINT

Maneuvering equipment in and through a vessel can be problematic. A compact unit – that can fit easily into a pump or engine room – is a must. Ours are up to 50% smaller than others in the industry. And certain parts, such as the inlet and outlet flanges, are removable. This provides additional installation flexibility for both new builds and retrofits.

LOW POWER DRAW

Instead of coupling two existing land-based treatment technologies, we decided to create and customize. Doing so enabled us to find the perfect balance between filtration and UV disinfection. We have also harnessed TrojanUV Solo Lamp and Driver Technology. The end result: The lowest power draw (up to half, in fact) of any filtration + UV systems in the industry.

CHEMICAL-FREE TREATMENT

Our integrated, filtration + UV disinfection treatment is inherently safe. Larger organisms are removed during filtration, and when microorganisms are exposed to the germicidal wavelengths of UV light, they are instantaneously inactivated and rendered incapable of multiplying. There is no need to transport, store or handle toxic chemicals, and no carcinogenic disinfection by-products will be formed in your tank.

EXPLOSION-PROOF

An explosion-proof version of each Trojan Marinex BWT system will be available for vessels where installation in a potentially explosive environment is required. Each will be certified in accordance with ATEX and IECEx, carry a T4 temperature class rating and are applicable for installation in zone 1 hazardous areas. Our complete Ex class rating is II 2 G Ex pIibIIC T4.

NO RISK OF CORROSION

Chemical and oxidizing treatment can increase the rate of corrosion and negatively impact your tank coatings. Fortunately, this is not the case when employing one of our systems. Filtration + UV is a simple, physical process where nothing – except for UV light – is added to the water. There is absolutely no increased risk of tank corrosion and no impact on coatings whatsoever.

UNINTERRUPTED OPERATION

It is not necessary to take the system offline to manually clean the filter or UV lamp sleeves. It’s equipped with an automatic filter backwash and UV lamp sleeve cleaning. Operation is continuous, treatment isn’t disrupted and manual maintenance procedures are minimal.

Simplified Maintenance & Supply Chain

Not only are our BWT systems easy to operate, they’re also easy to maintain. Routine maintenance is simple and intuitive, and no extensive training or water treatment expertise is required. Components (such as UV lamps, drivers and filter elements) are all easily accessed from a central location, and can be maintained by any crew member. These components are common throughout our entire product suite, so managing spare parts and inventory can be easily streamlined for additional cost savings.