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 discharged, untreated, into another can result in the introduction and spread of aquatic invasive and nuisance species. This is a serious threat to our environment.
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 businesses. 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. Several of the products developed by these businesses 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) water quality platform. Danaher is a Fortune 150, global science and technology leader with over $16 billion in revenue in 2016. Our combined 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.
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.

Our systems are purpose-built for the marine environment, and provide filtration + UV in a single, compact unit.
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, United States Coast Guard (USCG) and United States Environmental Protection Agency (USEPA) regulations – it is now an absolute necessity.

Trojan Marinex is here to help.
Prior to entering the ballast water treatment market, we spent the better part of a decade researching, developing, and engineering. We needed to fully understand the nature of the species present in ballast water, their susceptibility to treatment, and the laboratory methodology by which efficacy and compliance can be determined. In-depth research and science, in combination with rigorous product development, resulted in an environmentally sound, compact ballast water treatment system.

We focused on filtration + UV because these technologies:

- Are inherently safe and simple to operate
- Do not require chemicals
- Do not form any carcinogenic by-products
- Are not impacted by salinity, temperature, or pH

A CONVENTIONAL DESIGN SIMPLY WAS NOT AN OPTION

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

These include large footprint, high power demand, extra electrical cabinets, and increased power drop.

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

By combining the two treatment technologies into a single unit, we eliminate the need for additional piping, cables and cabinets.
NO INTERCONNECTING PIPE BETWEEN FILTRATION AND UV

INLINE LAMP DRIVER DRASTICALLY REDUCES WIRING AND CABINETS

UP TO 50% SMALLER THAN OTHERS IN THE INDUSTRY

DESIGNED TO FIT THROUGH NARROW HATCHES AND DOORWAYS
Since 1977, Trojan Technologies has been developing UV systems to treat the toughest of water qualities, and for the highest-risk conditions where human well-being is at stake. The largest UV drinking water facility in the world (in New York City) relies on TrojanUV systems to supply safe drinking water to nearly 9 million people. This system treats a flow rate of 395,000 m³/h – that’s equivalent to 66 VLCCs.

Today, Trojan is the world’s largest UV water treatment company, with systems treating a collective flow rate of over 8 million m³/h and over 1 million UV lamps in operation. Drawing on deep-rooted expertise and innovation, the UV technology incorporated into the Trojan Marinex™ BWT system truly is second to none.

PROPRIETARY UV 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:

• Life expectancy of beyond 12,000 hours of ballast water treatment operation
• Efficient performance throughout poor water qualities and cold water temperatures
• Consistently lower power draw, regardless of salinity, temperature or water quality
• Over 50 million operating hours throughout many water treatment applications

INLINE LAMP DRIVER

Mounting large electrical cabinets in a confined space is often arduous and time-consuming; so too is routing spools of cabling from the cabinets to the treatment system. However, because our drivers are connected directly to our lamps, footprint is reduced by 30% and 70% of cabling is eliminated.

Drivers are independently sealed at the factory and passively cooled during operation. Visual indicators enable crew to easily monitor lamp and driver status.
High UV output, low power draw, and life expectancy beyond 12,000 hours.
DISPELLING THE MYTH

UV can effectively treat extremely turbid ballast water, as long as the system is engineered to the highest of standards. The Trojan Marinex BWT system is tested and approved to one of the lowest UV transmittance (UVT) values in the industry, under full flow conditions. This dispels the myth that UV cannot be used in the poorest of water qualities.

UV CHAMBER & LAMP SPACING

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 system 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 will perform both effectively and efficiently.

UV Transmittance of Various Ports Around The World

<table>
<thead>
<tr>
<th>Port</th>
<th>UVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veracruz, MX</td>
<td>93%</td>
</tr>
<tr>
<td>Hong Kong, China</td>
<td>80%</td>
</tr>
<tr>
<td>Houston, USA</td>
<td>74%</td>
</tr>
<tr>
<td>Antwerp, Belgium</td>
<td>66%</td>
</tr>
<tr>
<td>Shanghai, China</td>
<td>55%</td>
</tr>
<tr>
<td>New Orleans, USA</td>
<td>53%</td>
</tr>
</tbody>
</table>

Water quality varies from port to port and day to day. A conventional ballast water treatment system – utilizing a land-based-designed UV system (i.e., designed to treat drinking water with 85% UVT) – won’t be able to provide the same treatment performance in lower UVT (e.g., 50%) water.

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.
OUR FILTER IS SPECIFICALLY ENGINEERED FOR BALLAST WATER TREATMENT

By identifying the inadequacies of off-the-shelf filters, and refining specific key features, we customized and engineered our solution with an industry-leading filter surface area, marine-tough construction, and an optimized automatic backwash process.

INTUITIVE APPROACH TO INNOVATION

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 have put filter systems through over 125 tests in four independent, land-based test facilities, one shipboard test facility and a shipboard pilot installation. In our opinion, this process – though arduous and humbling – was an absolute necessity. Not only did it enable us to custom-design and construct our own filtration system, it also allowed us to fully understand the capacities and limitations of existing filters, and conduct in-depth studies on a wide range of marine organisms and water conditions.

TESTED AND PROVEN IN EXTREME CONDITIONS

The combination of Total Suspended Solids (TSS) and high organic loading creates the most challenging conditions for filters. Furthermore, the loading rates of the suspended solids shipowners encounter during ballasting may be considerably higher than those seen under standard ballast water treatment system Type Approval testing. That’s why – to ensure uncompromising reliability – we’ve employed integrity, efficiency, and accelerated life tests. We’ve pushed our filtration to the limit, using punishing mixtures of challenge water and marine mud, to provide you with deserved reassurance and peace of mind.

Here’s a look at the marine mud that was used during a filter test in Bremerhaven, Germany. This mud was injected into the flow to demonstrate our system’s ability to continue treatment under extreme conditions.
CUSTOM-DESIGNED FILTER

By identifying the inadequacies of off-the-shelf filters, and refining specific key features, we proceeded to custom-design and construct our own filtration system – one that would work in unison with TrojanUV Solo Lamp Technology.

**Why it matters:** We engineered our system with an increased surface area and inherent filter redundancy to handle higher sediment loading, thus greatly reducing the risk of complete filter blockage. As a result, the filter elements are subjected to less strain during operation, which ultimately prolongs useful life.

**Why it matters:** Even the smallest imperfection or hole will allow organisms to pass through and jeopardize treatment. Our filter elements are strengthened with both internal and external support structures, constructed with premium duplex stainless steel, and are meticulously assembled in a quality-controlled facility.

**Why it matters:** The filter backwash process needs to efficiently and effectively remove captured material while optimizing the amount of water used. Ours systematically targets individual filter elements, seamlessly adjusts back pressure based on the state and cleanliness of each element, and recovers to a clean state without manual intervention.
32 micron filter elements, designed specifically for ballast water treatment.
Regardless of 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.

An explosion-proof version of each system is available for vessels where installation in a potentially explosive environment is required. Each are certified in accordance with the ATEX directive and IECEx scheme, carry a T4 temperature class rating and are applicable for installation in zone 1 hazardous areas.
<table>
<thead>
<tr>
<th>Flow Rate (m³/h)</th>
<th>Lamp Power (kW)</th>
<th>Dimensions (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>31</td>
<td>2.5 x 1.6 x 2.0</td>
</tr>
<tr>
<td>1000</td>
<td>42</td>
<td>2.6 x 1.7 x 2.2</td>
</tr>
<tr>
<td>1500</td>
<td>62</td>
<td>2.7 x 2.0 x 2.4</td>
</tr>
<tr>
<td>1250</td>
<td>55</td>
<td>2.7 x 1.9 x 2.4</td>
</tr>
</tbody>
</table>
COMPACT FOOTPRINT

POWER DISTRIBUTION & CONTROL CABINETS:
The main system power, fuses and breakers are all housed inside the power distribution cabinet. Inside the control cabinet are the electronic components that control and monitor the entire treatment system.

The control cabinet is equipped with a touchscreen Human Machine Interface (HMI) panel, which makes system monitoring and status checks quick and easy.

TROJANUV SOLO LAMP™ TECHNOLOGY:
The second treatment stage is UV. As the water flows through the array of TrojanUV Solo Lamps, organisms’ reproductive capabilities are destroyed, rendering them non-reproductive and unable to grow, colonize or cause an infestation. During deballasting, water bypasses filtration and is again directed through the UV chamber for treatment.
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.

INLINE LAMP DRIVER: Drivers are located directly on top of the lamps, thus eliminating the need for additional cabinets and cables. Intuitive diagnostics provide immediate visual lamp status.

FILTER: The first treatment stage is filtration. This is when larger organisms and particles are removed. The filter is equipped with an automatic backwash. Filtration only occurs during ballasting (it is automatically bypassed during deballasting).

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.
Our product suite obtained IMO Type Approval from DNV GL on behalf of the Norwegian Maritime Directorate in March 2014. In August 2014, it was issued Alternate Management System (AMS) acceptance by the USCG.

Five facts about our Type Approval:

1. Testing was conducted under the supervision of DNV GL (DNV GL is certified as an Independent Lab by the USCG) in accordance with United States Environmental Protection Agency (USEPA) Environmental Technology Verification (ETV) Ballast Water Protocol. The ETV protocol is a key testing requirement for systems to obtain USCG Type Approval. It also offers provisions to accept alternative testing methods to prove system efficacy.

2. Land-based testing was completed at the DHI Maritime Technology Evaluation Facility in Hundested, Denmark and shipboard testing was completed on board the Training Ship Golden Bear (TSGB) – both are part of DNV’s network of subcontractors approved by the USCG for testing BWT systems.

3. Tested and approved to one of the lowest UV transmittance (UVT) values in the industry, under full flow conditions.

4. Land-based testing was conducted up to 1250 m³/h to verify the efficacy of the system at higher flow rates, meeting the requirements of IMO circular BWM.2/Circ.33 (Guidance on the Scaling of Ballast Water Management Systems).

5. Tested in all three salinity ranges – brackish, fresh and marine.
INSTALLATION FLEXIBILITY

Until now, lamp drivers have needed additional electrical cabinets to house and protect them from the harsh elements. However, our inline lamp drivers give a new meaning to compact footprint. They connect directly to the lamps, eliminating the need for additional cabinets and cables.

Our compact technology integration is unique. Others keep their treatment methods separate, which increases footprint and makes for cumbersome retrofitting.

All active components in our units are fitted within the same housing, and no extra pipes or fixtures are needed. Also, drydock installation is not always necessary; installation during voyage is possible.

CONVENTIONAL DESIGN
(one filter + four UV = 1,000 m³/h filtration capacity)

OUR DESIGN
(two Trojan Marinex™ BWT 500 units = 1,000 m³/h)

Here is an example installation of a Trojan Marinex BWT 250 unit. Total footprint is 3m², treating 250 m³/h.

All active components in our units are fitted within the same housing.
LOW POWER DRAW

We’ve harnessed the true power of TrojanUV Solo Lamp Technology, and found the perfect balance between filtration and UV. The end result: The lowest installed power draw (at least 50% less) of other systems in the industry.

Some systems on the market are comprised of existing land-based treatment technologies. When doing this, thorough system optimization is difficult and can result in an increased power draw. That’s yet another reason why we decided to create and customize our system from the ground up, and integrate filtration + UV in a single, compact unit.

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.

<table>
<thead>
<tr>
<th>Filtration + UV</th>
<th>Other Filtration + UV</th>
<th>Filtration + Electrolysis</th>
<th>Combined Multiple Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trojan Marinex BWT System</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Low Power Requirements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>No Chemicals Used</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>No By-product Formation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>No Corrosive Effects</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Filtration + UV is a pure, physical process. Absolutely no by-products are formed.

Some systems may have a total installed power draw requirement much higher than when operating at ideal conditions; this often necessitates that an auxiliary electrical source be added. The chart above compares the power consumption of a Trojan Marinex BWT 1000 to other systems.
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.

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 is not disrupted and manual maintenance procedures are minimal.

GLOBAL SUPPORT NETWORK

Our systems are designed to require minimal service interventions. However, if you are ever in need of urgent support, our worldwide partner network is on standby, ready to assist.
# SPECIFICATIONS

<table>
<thead>
<tr>
<th>Treatment Rated Capacity (m³/h)</th>
<th>150</th>
<th>250</th>
<th>500</th>
<th>750</th>
<th>1000</th>
<th>1250</th>
<th>1500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BALLAST WATER TREATMENT UNIT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>316L Stainless Steel or Better</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>System Pressure Loss (Clean)</td>
<td>&lt; 0.1 bar</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Dry Weight (kg)</td>
<td>760</td>
<td>1300</td>
<td>1500</td>
<td>2100</td>
<td>3100</td>
<td>3400</td>
<td>4600</td>
</tr>
<tr>
<td>Wet Weight (kg)</td>
<td>1300</td>
<td>2200</td>
<td>2600</td>
<td>4100</td>
<td>5500</td>
<td>7700</td>
<td>8900</td>
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<tr>
<td>Max Installed Power Requirements (kW)</td>
<td>9.2</td>
<td>14.2</td>
<td>26.2</td>
<td>33.2</td>
<td>44.2</td>
<td>57.2</td>
<td>64.2</td>
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<tr>
<td>Explosion-proof*</td>
<td>Certified in Accordance With the ATEX Directive and IECEx Scheme</td>
<td></td>
<td></td>
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<tr>
<td>Inlet/Outlet Connections</td>
<td>DN150</td>
<td>DN200</td>
<td>DN300</td>
<td>DN400</td>
<td>DN400</td>
<td>DN500</td>
<td>DN500</td>
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<td><strong>VERTICAL CONFIGURATION</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>H x W x D (m)</td>
<td>2.2 x 1.0 x 1.3</td>
<td>2.3 x 1.1 x 1.6</td>
<td>2.4 x 1.1 x 1.7</td>
<td>2.5 x 1.6 x 2.0</td>
<td>2.6 x 1.7 x 2.2</td>
<td>2.7 x 1.9 x 2.4</td>
<td>2.7 x 2.0 x 2.4</td>
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<tr>
<td><strong>HORIZONTAL CONFIGURATION</strong></td>
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<td>H x W x D (m)</td>
<td>1.4 x 1.8 x 1.3</td>
<td>1.4 x 2.0 x 1.6</td>
<td>1.5 x 2.2 x 1.7</td>
<td>1.8 x 2.4 x 2.0</td>
<td>2.0 x 2.4 x 2.2</td>
<td>2.2 x 2.5 x 2.4</td>
<td>2.4 x 2.5 x 2.4</td>
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<tr>
<td><strong>UV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV Lamps</td>
<td>TrojanUV Solo Lamp (LPHO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning System</td>
<td>Automatic Wiping System</td>
<td></td>
<td></td>
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<tr>
<td><strong>FILTRATION</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Effective Pore Size</td>
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<td>Filter Material</td>
<td>Super Duplex</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Cleaning System</td>
<td>Automatic Backwash Cleaning System</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>CABINETS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Cabinet</td>
<td>H x W x D (m)</td>
<td>0.7 x 0.6 x 0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Distribution Cabinet</td>
<td>H x W x D (m)</td>
<td>1.1 x 1.2 x 0.3</td>
<td>1.1 x 1.4 x 0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Ex specifications may vary

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