

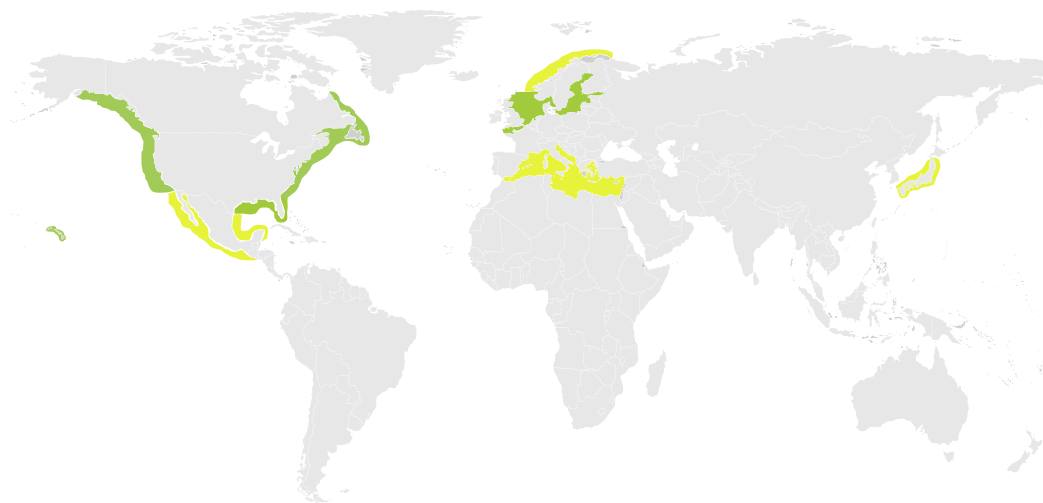
MarinePaq scrub water treatment



INTRODUCTION

APATEQ's scrub water treatment system "MarinePaq" is the green and cost-efficient one-stop solution for the treatment of wastewater resulting from the washing of exhaust gases generated during combustion in the engines of large ships. The MarinePaq can be implemented as on-board or onshore installation. For the latter, APATEQ combines field proven membrane filtration technology with unique process technologies, setting new standards in terms of performance, quality, safety and economic value as well as ecological efficiency. Effluent from the MarinePaq is suitable for recirculation or direct discharge into the open sea, coastal area and harbour, meeting strictest international legislation.

Shipping is a global industry. Running with heavy bunker oil, shipping fleets produce emissions harming the fragile ecosystem of the sea and coastal areas of many regions worldwide. Consequently, stricter legislation on emissions started to be put in place, such as the IMO's (International Maritime Organization) resolution to limit the sulphur content of marine fuel down to 0,1% in the ECA (Emission Control Areas such as, among others, North Sea and English Channel, Baltic Sea; see: IMO MARPOL Annex VI). These are regions where neighbouring states have shown that emissions to air have particular impact on human health and the environment. The sulphur content of the fuel is directly related to the sulphur oxide (SOx) emissions from the ships as SOx is produced by oxidation in the combustion chamber. The resolution also limits the extent of nitrogen oxide emissions (NOx) to the air, depending on the ship's construction date (IMO MARPOL Annex VI, Regulation 13, Tier I, II and III).



Existing ECA

Possible future ECA

*Emission Control Areas (ECA)
according to IMO*

In order to comply with these regulations, shipping companies can switch to low sulphur fuel or install devices such as scrubber systems for the purification of exhaust gases resulting from heavy bunker oil usage. The latter is mostly used in practice today as low sulphur oil is more expensive than heavy bunker oil and besides back-fitting the engine of the vessel accordingly would mean substantial additional costs for ship owners. Thus, the implementation of scrubber systems, in open or closed loop design (according to present legislation) is mainly wide spread in practice today. Scrubber systems produce scrub water in large (open loop) or smaller extent (closed loop). Consequently, IMO has foreseen limiting values for the scrub water in terms of pH, PAH and turbidity before discharging it into the sea (IMO MEPC.184 (59)). This makes a certain kind of treatment necessary. For a discharge in coastal areas, including harbours, specific national regulations are put into place, preventing the relocation of the issue of emissions from the air to the sea. Existing regulations put into place by the IMO or the local governments are subject of steady tightening. Limiting values for discharge into the sea will be decreased to minimum levels of overall pollution, meaning scrub water treatment systems that can fulfill existing regulations may not be sufficient in the future. Shipping companies should be aware of this before they take the decision for the investment in a scrub water treatment system based on current legislation. Clean-tech innovator APATEQ provides green and cost-efficient solutions for scrub water treatment, as an on board or onshore installation for a centralized treatment. Thus, shipping companies can treat scrub water from their vessels by themselves, saving expensive water disposal costs for hauling the scrub water to the nearest industrial wastewater treatment facility and they are independent from the availability of external water service providers saving time and gaining

flexibility of their fleet. When implementing the MarinePaq technology for their fleet, shipping companies can benefit from a very fast Return on Investment (ROI) of typically a few months. The performance of APATEQ's MarinePaq is in full compliance with present legislation and can be easily adapted to meet future, tighter legislation, as the modular design of the system allows not only capacity increases but also performance increases.

Scrub water is typically highly contaminated with heavy metals, hydrocarbons and soot arising from the combustion of the heavy bunker oil used. Current treatment technologies available on the market such as hydro-cyclones and centrifuges are often overstrained with scrub water, especially in terms of eliminating the tiny lightweight soot particles that act as carriers for hydrocarbons. APATEQ excels above other technologies available on the market by combining field proven membrane technology with innovative process technologies, ensuring a reliable, failure-free operation at low operation expenses. By means of APATEQ's MarinePaq solution, even the smallest particles are reliably removed, providing an effluent that allows a direct discharge into the sea, coastal areas and harbour according to strictest international legislation. The membranes used for the treatment excel by a lifetime beyond five years before they have to be thoroughly cleansed or exchanged. Optimized membrane performance combined with constant automatic backwash allows effortless maintenance procedures with long intervals. Sludge arising from the treatment is compacted by an integrated chamber filter press and safely disposed of onshore to appropriate facilities such as landfills. The MarinePaq is designed for a 24/7 operation with highest degree of automation.

MarinePaq benefits

- Low operation costs
- Fast ROI within a few months
- No expensive scrub water hauling required
- No dependency on the availability of external water service provider
- Modular design easily allows performance and capacity increases
- Long lasting membranes
- Low maintenance efforts
- Reliable 24/7 operation

TECHNICAL SPECIFICATIONS

MarinePaq onshore

	MarinePaq 25	MarinePaq 50	MarinePaq 100	MarinePaq 250	MarinePaq 500
Treatment capacity (m³/day)	25	50	100	250	500
Implementation (sea containers)	2x40'	2x40'	fixed installation	fixed installation	fixed installation
Power consumption (kWh)	30	40	70	160	300
Weight, dry (t)	30	35	project specific	project specific	project specific
Membrane lifetime (years)	> 5	> 5	> 5	> 5	> 5



Containerized
MarinePaq module

Typical influent values (closed loop) vs. effluent values (e.g. in compliance with direct discharge into the seawater in a port in the northern part of Europe)
These values are exemplary and indicative only.

	Unit	Scrub water content	Guaranteed effluent values
TSS (including soot)	mg/l	300 - 1.500	< 10*
Hydrocarbons	mg/l	1 - 10	< 5
Sulphite	mg/l	200 - 2.500	< 5
Nitrite	mg/l	0 - 400	< 1
Nitrate	mg/l	0 - 440	< 10*
V**	mg/l	10 - 30	< 2
Ni**	mg/l	2 - 4	< 0,5
PAH	µg/l	25 - 100	< 10
COD	mg/l	1.200 - 3.000	< 200*
pH level	pH	5,3 - 7,8	> 6,5**/**

** If the effluent was discharged in a large sewage water treatment plant, the target value would be less strict.*

*** The source of heavy bunker oil could make these values vary even more in theory.
 Depending on the fuel supplier heavy metals could also be copper, chrome and rubidium.
 The MarinePaq can handle all these heavy metals and variations.*

**** The pH level of the effluent is adjustable according to the specific requirements.*

MarinePaq on board

The on-board version of the MarinePaq produces an effluent that complies with the IMO MARPOL Annex VI norms for open sea discharge in the ECA. The IMO MEPC.184(59) guidelines require three wash water parameters to be continuously monitored if discharged to sea:

Acidity: pH > 6,5
Turbidity < 25 FNU (Formazine Nephelometric Unit)*
PAH (Polycyclic Aromatic Hydrocarbons) < 0,05 mg/l

**The scrub water treatment system should minimize suspended particulate matter, including heavy metals and ash.*

PROCESS TECHNOLOGY

The onshore MarinePaq is based on a five-step treatment system designed to fit into several shipping containers or in a fixed installation, depending on the flow capacity. By stacking the containers one on top of the other, the MarinePaq can be easily installed in an existing harbour by requiring a minimum footprint, which is always an important factor there. Its effluent is in compliance with the respective discharge limits, whereas the requirements may vary depending on local regulations.

Pumps drive water from the customer's own storage tank to the first treatment step, a chemical-physical pre-treatment. It removes nitrite, sulphite, partially heavy metals and hard (non-biodegradable) COD.

By means of APATEQ's unique ultrafiltration system soot and remaining suspended solids as well as free and emulsified oil are removed from the scrubber water. Specially conditioned membranes are operated in a cross-flow mode, reliably removing TSS including soot to a level of below 1 mg/l. The easily replaceable membranes of the MarinePaq excel by a long lifetime of more than five years and long intervals in between its effortless CIP (Clean In Place) procedures. To ensure a constant operation at highest performance levels between the CIP's, frequent automatic backwash is programmed into the system.

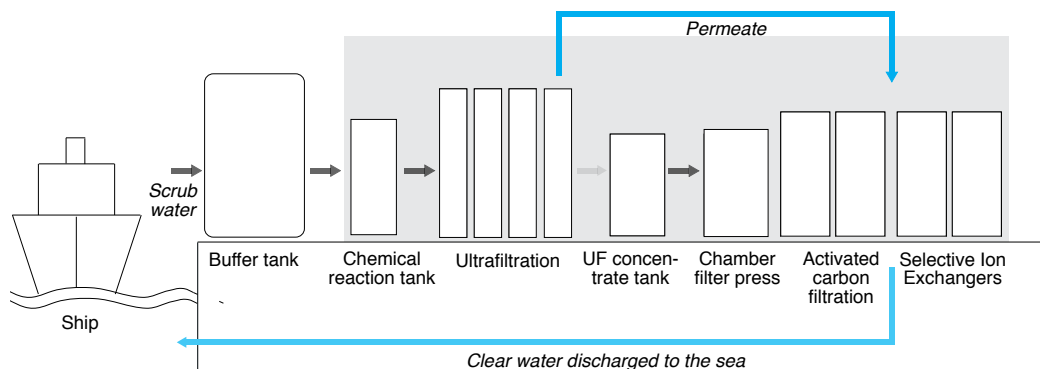
Subsequently, a granulated activated carbon filtration (GAC) further reduces COD from the

water by absorbing the contaminants. The activated carbon used for the MarinePaq is regenerated, ensuring lowest operation costs.

The post-treatment is done by selective ion exchangers that remove nitrate and heavy metals to the needed low concentration for the direct discharge limits.

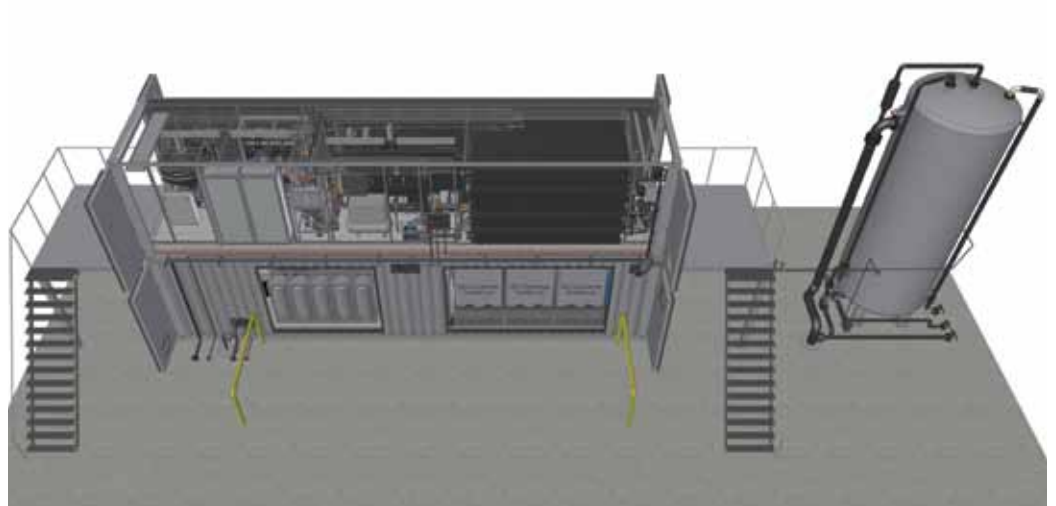
Finally, sludge dewatering takes place with a fully automated chamber filter press, including an automatic filter cloth-cleaning process. The sludge from the chemical pre-treatment and the membrane concentrate is pumped into the sludge storage tank controlled by a motor valve. A pressure probe measures the sludge level in the sludge tank and regulates the motor valve. Next, with long lifetime and smooth operation, a bespoke compact sludge dewatering device thickens the sludge to a level of 30 - 40% DS (Dry Solids). The sludge volume is therefore minimized, which decreases the disposal cost of the waste stream of the plant.

MarinePaq onshore handles all kind of scrub water including nitrate and nitrite. It is customized in a way that its effluent is in compliance with local regulations for discharge into the harbour basin. The modular design of the system allows an easy upgrade of the treatment system in case of changing influent values or tougher effluent requirements.

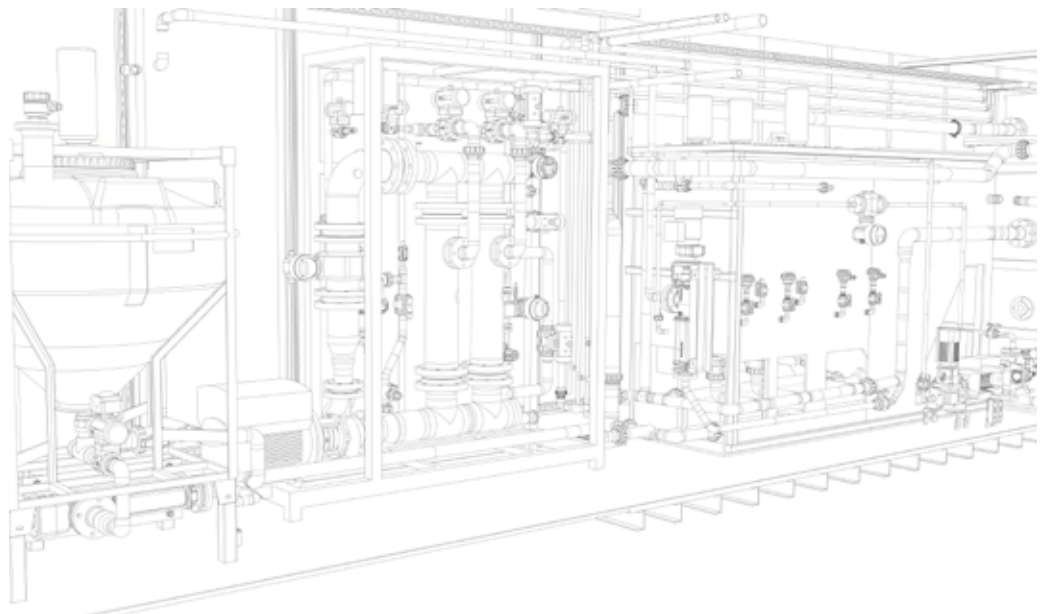


Process description
MarinePaq onshore

*Schematic split into two
containers stacked one
on top of the other*



*Interior view container
module with ultrafiltration*



SPECIAL FEATURES

Modular Design

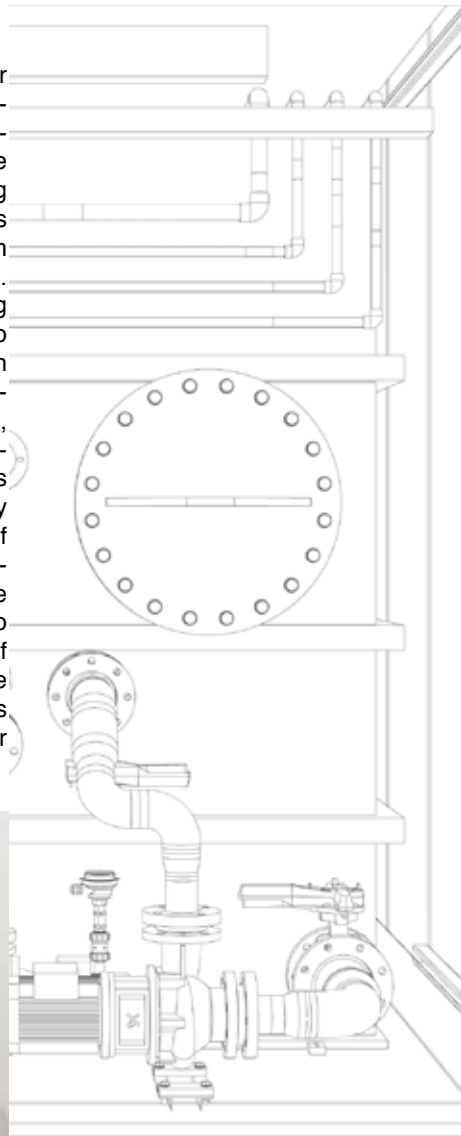
The MarinePaq is designed in a modular way to provide both flexibility and reliable operation. By means of the system's modular design, the MarinePaq can easily be adapted according to customer needs. As standard MarinePaq modules are available off the shelf, construction changes of running systems (such as capacity increase of the system or changed effluent quality requirements) can be effected quickly.

Built Quality

MarinePaq is constructed for a long service life and continuous operation by meeting the most stringent standards in a highly corrosive environment. Corrosion-resistant, weight-saving piping is used for the entire installation to ensure a failure-free, long-lifetime operation of the MarinePaq system, performing under toughest conditions, i.e. salty seawater with a very high load of contaminants.

Automatic Control

As all of the APATEQ's water and wastewater treatment systems, the MarinePaq is fully automated and can be remotely monitored and controlled. The operator does not need to supervise the plant on-site thanks to an app displaying the plant's graphic user interface, that allows the plant to be controlled and monitored from a desktop computer, a tablet or a smartphone. The control system is constantly optimizing the process to perform the best with respect to energy / operation cost efficiency and emission reduction. Through remote reporting and secure data storage of the system performance, APATEQ is able to record the operational performance of the MarinePaq. Sensors at various places of the treatment process automatically measure pH, temperature, turbidity and redox of the scrub water. Only regularly quick tests concerning the levels of nitrite, nitrate and sulfite and, if required, COD in the raw water need to be conducted by a trained operator by means of a dedicated measuring device to determine the amount and composition of chemical additives and coagulants required for the prevailing water characteristics.



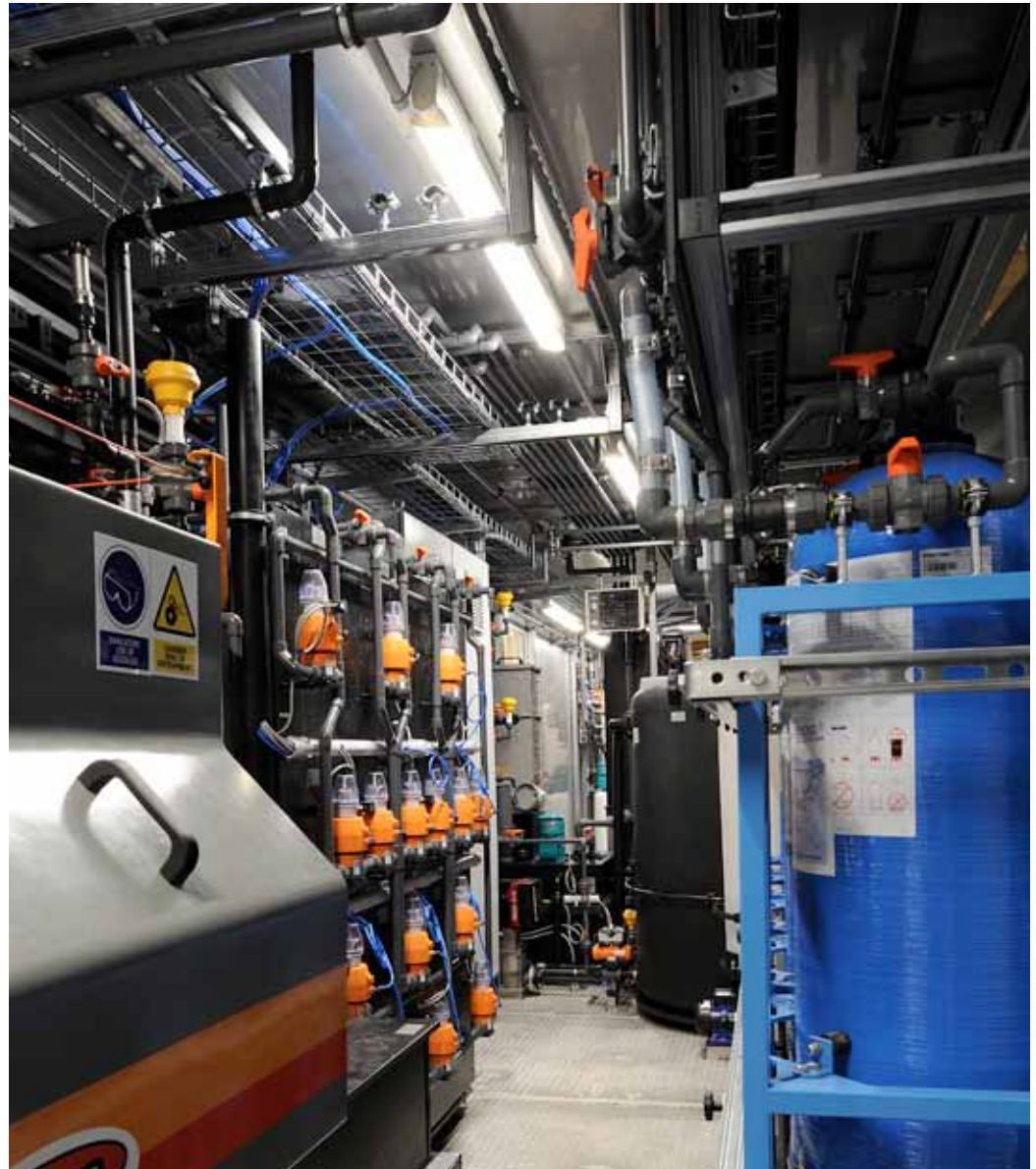
*left: Interior view MarinePaq module
right: On-site control cabinet inside MarinePaq*

OPERATION, MAINTENANCE & TRAINING

As the MarinePaq system is fully automated, only a regular, short supervision on site at the plant is required, substantially saving manpower and thus operation costs. The ultrafiltration membranes used for the MarinePaq onshore solution excel by smooth operation and a lifetime greater than five years. The cleaning of these membranes is performed automatically and

effortlessly, allowing long intervals in between the CIP (Clean In Place) procedures.

Equipped with an on-site control system with touch screen, the plant is easy to operate. The APATEQ engineering team provides crew training for a safe operation of the MarinePaq in the course of the plant commissioning.



*Interior view
MarinePaq module*

ABOUT APATEQ

Clean-tech innovator **APATEQ** provides green and cost-efficient one-stop solutions for selected markets in the water and wastewater industry by means of unique, membrane-based systems with an extremely long lifetime of reliable operation.

One of the focus areas is the treatment of wastewater resulting from the washing of exhaust gases generated during combustion in the engines of large ships: APATEQ's "MarinePaq" enables a high-efficiency scrub water treatment at costs typically of one order of magnitude lower than the ones offered by competition, thus excelling above all other solutions available on the market. Our plants meet toughest international legislation and are in compliance with even the most onerous environmental standards. The effluent from our systems is suitable for direct discharge, reuse or irrigation, saving our most precious resource: fresh water.

TESTIMONIALS



Fini Hansen, Technical Superintendent
SCANDLINES Danmark ApS:

"SCANDLINES as a shipping company has an environmental responsibility. We want to contribute to the preservation of the fragile marine ecosystem by cleaning our exhaust gases and by only discharging water of the highest quality back into the ocean. APATEQ's MarinePaq offers a unique solution to discharge the cleaned water even into the harbour basin."



Paul Marceul, Manager Cluster Maritime
Luxembourg:

"Luxembourg's Cluster Maritime is proud of its member APATEQ and the company's success in setting new standards for clean technology in the shipping industry. Luxembourg's red lion flag is a sure token for quality. By means of outstanding technologies such as APATEQ's MarinePaq system for scrub water treatment, Luxembourg broadens its role to a service, and besides, solution provider to the shipping industry."



Rolf Hollmén, CEO Björneman Water, Sweden:

"Our advisory team possesses decades of experience in the maritime sector and is strongly committed to reducing the negative impact of vessel emissions on our marine environment. To us, APATEQ's MarinePaq significantly contributes to the realization of sustainable shipping in the Baltic Sea and the North Sea area."



Paul Schosseler, Deputy Director of the Environmental Department ERIN,
Luxembourg Institute of Science and Technology (LIST):

"APATEQ's management team comprises experts with decades of experience in water and wastewater treatment and global industrial product manufacturing and commercialization. Within shortest time they managed to develop industrial-scale installations of its unique systems for membrane-based scrub water treatment, thus positioning APATEQ on new markets through continued R&D efforts."

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