



PureSO_x

Exhaust gas cleaning





Exhaust gas cleaning

Alfa Laval's PureSO_x removes sulphur oxides from the ship's exhaust gas by scrubbing it with seawater or freshwater.

- Short payback time (1 to 2 years).
- Sulphur removal rate >98% (exceeding IMO requirements).
- Cost-saving solution (able to operate on HFO instead of expensive low-sulphur MGO).

Introduction

The unique hybrid design of Alfa Laval's PureSO_x gives both environmental and economical advantages.

Shipowners can continue operating on heavy fuel oil instead of more expensive marine gas oil, while still meeting the strict International Maritime Organization (IMO) regulations regarding sulphur oxide emissions.

Legislation

In October 2008 the Marine Environment Protection Committee (MEPC) of the IMO agreed on the progressive reduction of the maximum sulphur content in fuels used on board ships. The revised Marpol Annex VI regulations reduce the global sulphur cap to 0.5%, effective from 1 January 2020. The limit applicable in Emission Control Areas (ECA) will be reduced to 0.1%, effective from 1 January 2015. Exhaust gas cleaning systems that reduce the emission of sulphur oxides to the same extent are approved by IMO.

Experience

Alfa Laval has more than 40 years of experience supplying scrubbers as an integrated part of inert gas systems on board ships. During 2008, our experiences from these systems were used to design and test an exhaust gas cleaning system at the MAN Diesel (1 MW engine) test facilities in Denmark.

Installation on large Ro-Ro vessel

The knowledge and experience from these tests was successfully used to design an entire PureSO_x system on board the DFDS Ro-Ro vessel "Ficaria Seaways".

A modular and flexible exhaust gas scrubber design was chosen with a high degree of operational flexibility, and future possibilities for upgrading the equipment.

Installed after the 21 MW MAN engine, it is by far the world's largest exhaust gas cleaning system on board a ship. The design work was carried out in close co-operation with the marine engineers from DFDS and MAN Diesel.

A comprehensive test scheme was performed for a range of operating conditions to secure full compliance with the 2015 Marpol Annex VI legislation.

MAN Diesel has participated intensively in the design work to ensure a smooth and safe interface with the main engine.



Concern.
Commitment.
Contribution.

Pure Thinking from Alfa Laval

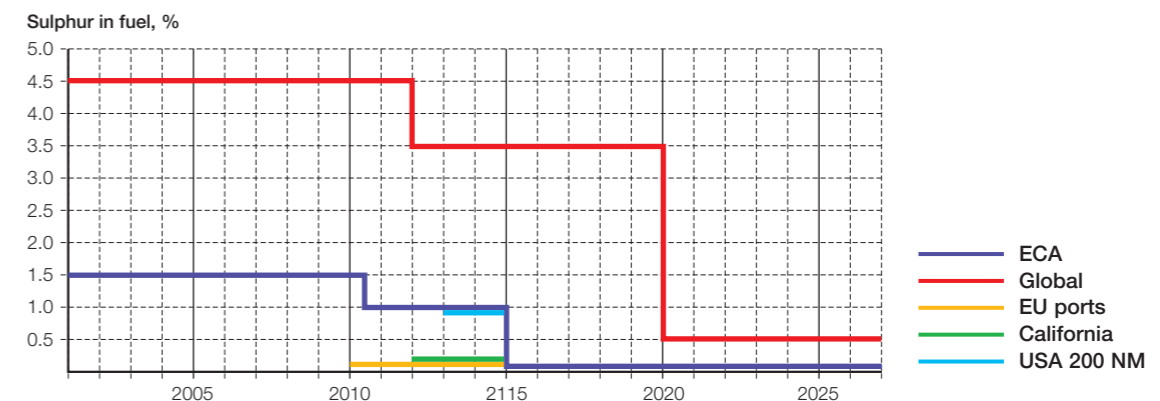
Long service at sea has given us a deep understanding of the marine environment and the demands on industry.

We are committed to efficient solutions that save energy and support you in meeting environmental regulations.

Meeting these demands requires a commitment that cannot be underestimated.

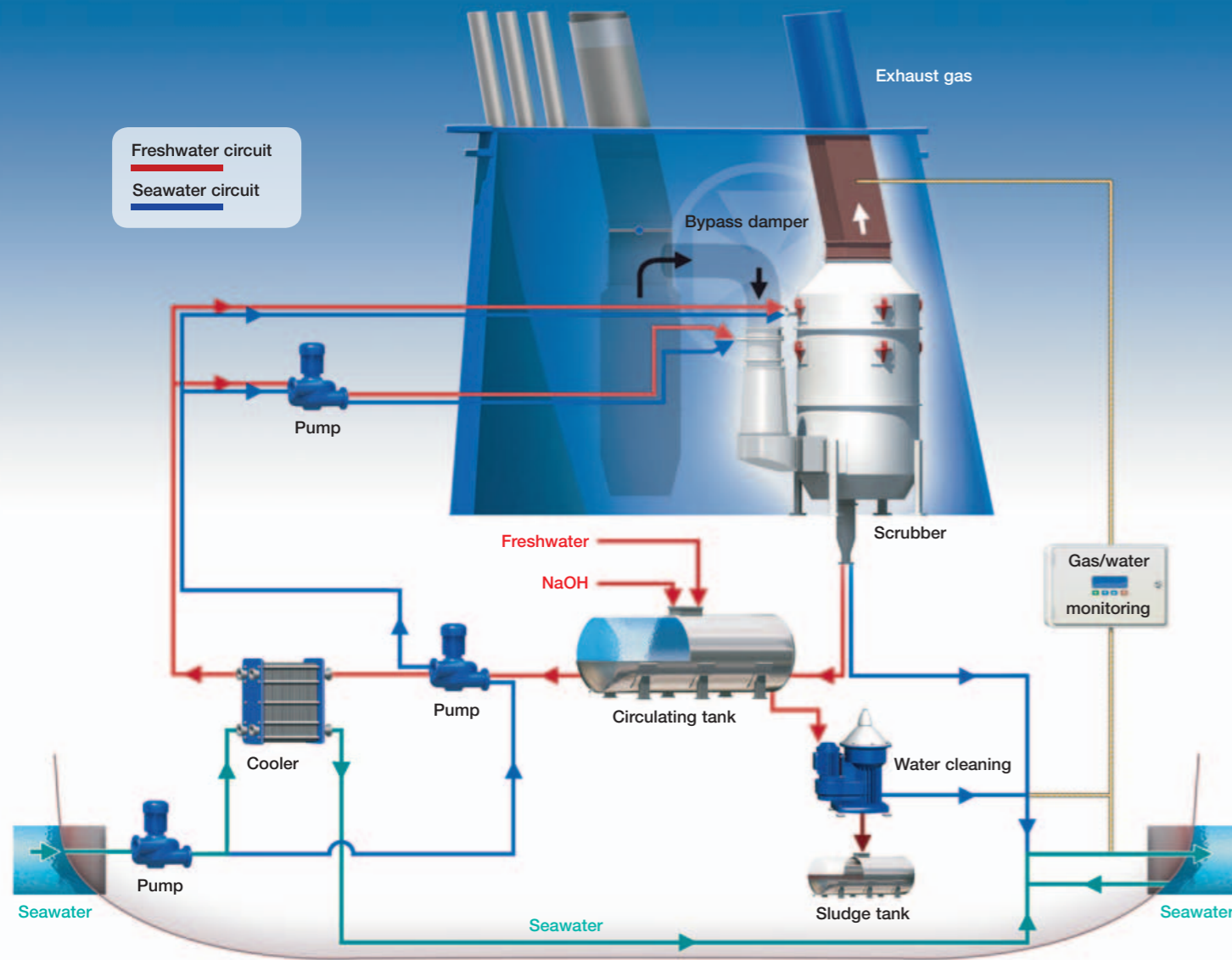
For Alfa Laval's part, the evidence of that commitment can be seen in our actions and in the strength of our ongoing contribution.

Legislation



How does PureSO_x work?

Schematic overview of the PureSO_x hybrid system.



PureSO_x facts:

- Cost-saving solution (able to operate on HFO instead of expensive low-sulphur MGO).
- Complies with MARPOL Annex VI – MEPC 59.
- Sulphur removal rate >98% (exceeding IMO requirements).
- PureSO_x is available as a Seawater, Freshwater or a Hybrid system.
- Traps up to 80% of particulate matter.
- Proven technology, currently the largest scrubber installed on a vessel after a 21MW main engine.
- Able to operate in low alkalinity waters.
- Power consumption in operation: approximately 1.5% of engine power.

Hybrid system

Alfa Laval designed the hybrid system for maximum flexibility, combining a seawater and a freshwater system.

In open sea, PureSO_x operates on seawater, providing savings on caustic soda and freshwater. While in low alkalinity waters, harbours and estuaries, the system can operate on freshwater in a closed loop. In freshwater mode only small quantities of sludge are generated, which can be handled as normal engine sludge.

Switching between seawater and freshwater mode can be done manually or automatically, based on the ship's GPS positioning.

To minimize energy consumption, water flow is automatically adjusted to engine power. The system is also designed to vary water flow according to the sulphur content of the fuel.

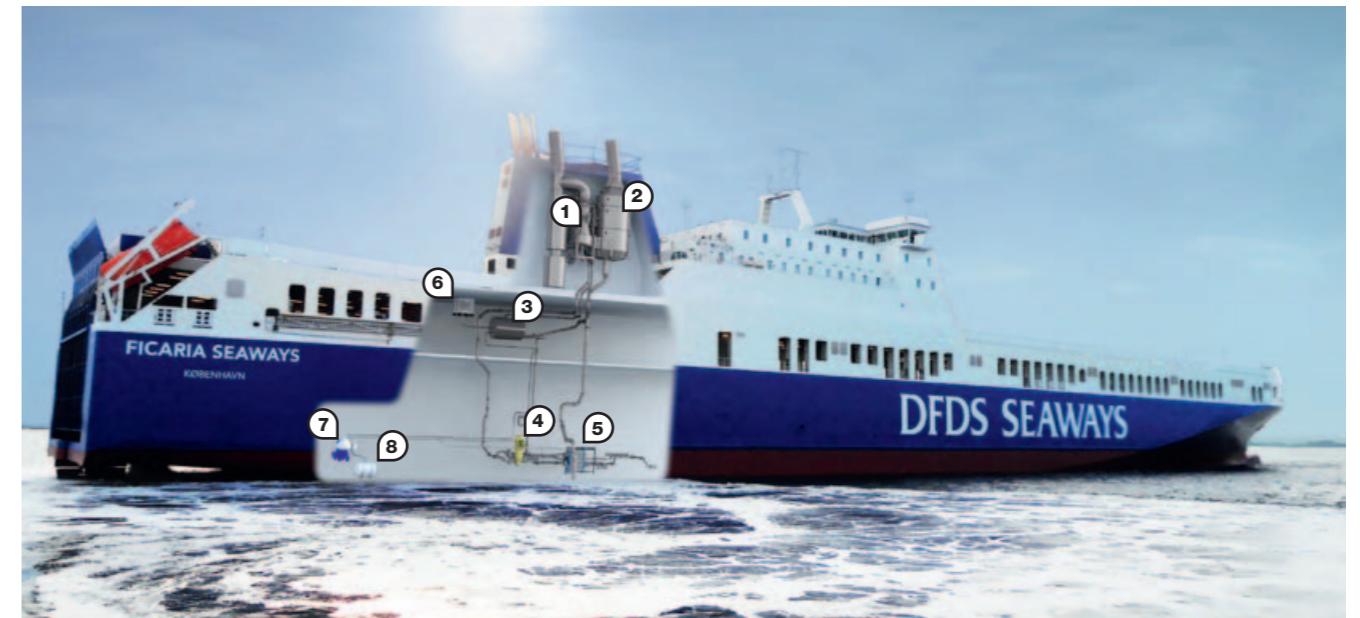
PureSO_x has been developed with design upgrades in mind, to ensure compliance with future legislation.

Advantages of the hybrid system:

- Runs on seawater in open sea whenever possible, for lowest cost and ease of operation.
- Zero discharge when required, in some ports, estuaries or sensitive areas.
- Able to cope with low-alkalinity waters (Baltic, estuaries and rivers).
- No switching between MGO/HFO, for maximum fuel savings.
- Maximum flexibility.

Retrofit of the Ficaria Seaways

In 2009, Alfa Laval installed the world's largest scrubber on board the Ficaria Seaways. The vessel is propelled by a 21 MW MAN B&W two-stroke main engine that emits 200,000 kilograms of exhaust gas per hour. The fuel burned by the Ficaria Seaways is heavy fuel oil with a sulphur content of 2.2%. The exhaust gas is washed in the scrubber to reduce the SO_x content to the 0.1% level required by IMO regulations that come into force in 2015.



The Ro-Ro vessel "Ficaria Seaways" with PureSO_x installed.

- 1) Jet scrubber
- 2) Absorber
- 3) Circulation tank
- 4) Circulation pump
- 5) Plate heat exchanger
- 6) Caustic soda tank
- 7) Water cleaning
- 8) Sludge tank

Multiple-inlet systems

Main and auxiliary engines can be combined into one system.

Alfa Laval has developed PureSO_x systems with multiple inlets in order to limit the number of scrubbers on board the vessel. Main and auxiliary engines can be combined in one system. The energy needed to drive the PureSO_x pumps is automatically adjusted to the engine.

Benefits of the multiple inlet system include:

- **Lower investment costs.** By combining multiple engines significant savings are achieved on equipment and installation cost.
- **Smallest footprint.** As space is limited on existing vessels, one multiple inlet system can be the solution where single inlet systems will not fit.
- **Reduced weight.** A multiple inlet system saves on weight, preventing possible stability issues.

Dimensions and weight

The dimensions and weight of the PureSO_x system are dependent on factors such as the percentage of

sulphur in HFO, the alkalinity of the seawater, and the amount of exhaust gas that needs to be cleaned.

Engine MW	Diameter m	Length m	Height m	Dry weight tonnes	Operational weight tonnes
4	2.0	3.5	5.6	11	13
8	2.9	4.9	7.2	15	18
12	3.5	5.8	8.1	18	22
16	4.0	6.7	9.0	22	29
20	4.6	7.8	10.0	25	35
24	4.9	8.3	10.4	28	41
32	5.9	10.6	11.6	38	52
55	7.7	13.9	14.4	62	86

The table provides indicative information on sizes and dimensions per engine size (based on a single-inlet PureSO_x system).



Multiple-inlet PureSO_x system for main engines and auxiliary engines.

Water cleaning

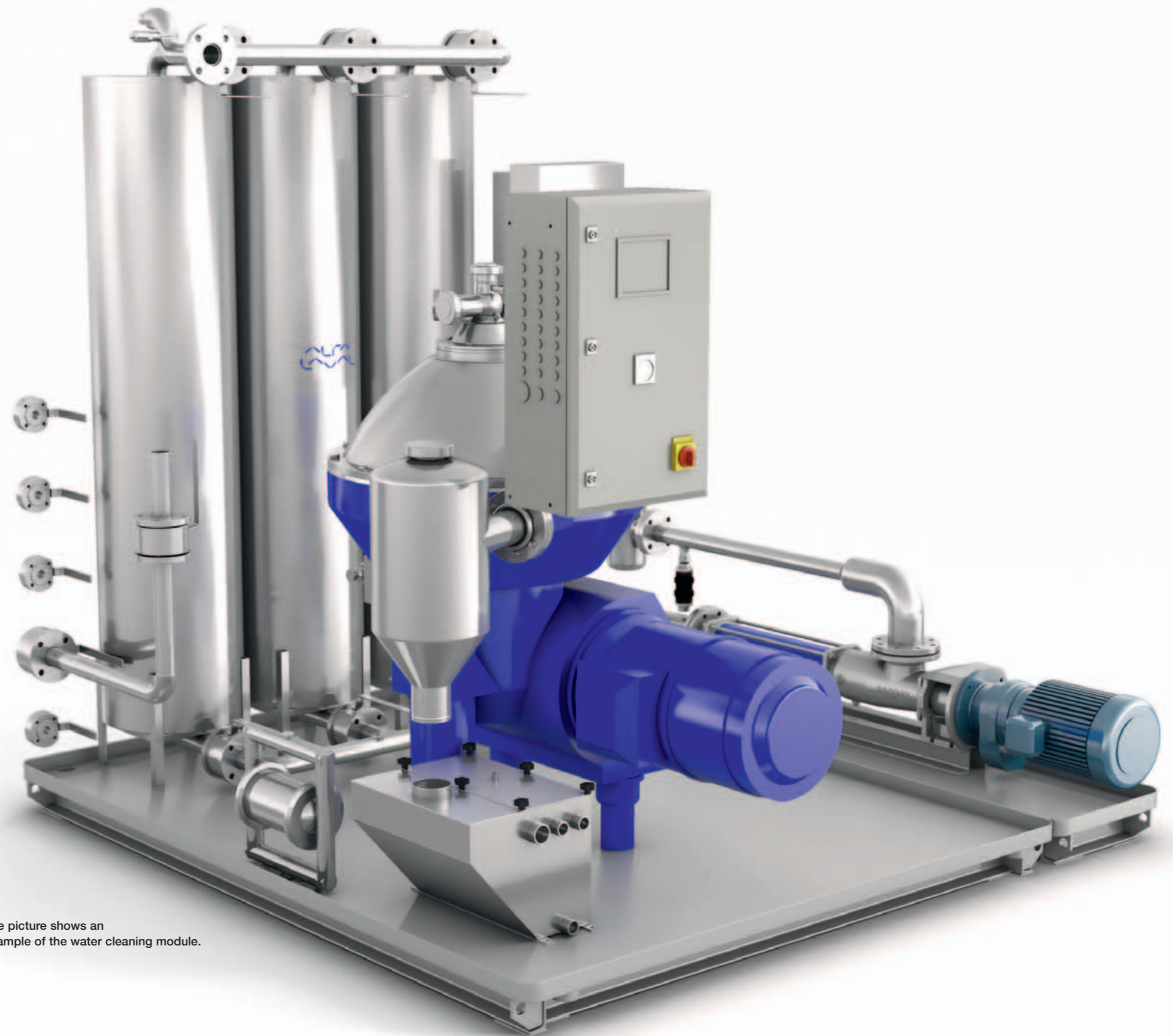
The Alfa Laval cleaning system secures compliance with IMO Marpol Annex VI wash water criteria.

Alfa Laval high-speed separation technology is used to clean the effluent, ensuring compliance with IMO wash water criteria according to Marpol Annex VI. This technology is well proven, and the footprint is smaller than many other water cleaning solutions. The unit measures, controls and logs the wash water content.

- **Simple process.** No additional process steps needed, such as generation of air, ozone or other media.
- **Minimized sludge generation.** The high-speed separation technology is without doubt the solution that generates the driest sludge in the lowest quantities, with the possibility to clean the wash water beyond the IMO criteria should stricter regulations come into force in the future.
- **Instant bleed-off.** Excess cleaned scrubber water can be discharged overboard instantly. No settling time, filtering of effluent or floatation with flocculants and skimming needed.
- **Effective removal of particles hazardous to health.** Dangerous particulate matter for humans and animals is effectively trapped in the wash water and cleaned out in a simple one-step system solution.
- **Flexible and space saving design.** The design spans the full engine power range. With its modular design and small footprint, the system fits equally well into existing ships and new builds.

Engine power (MW)	Footprint (m)	Electrical power (kW, nominal)
0-8	2.5 x 2.5	15
9-27	2.5 x 2.5	35
28-47	2.5 x 2.5	45
48-56	5.0 x 3.0	70

The table provides indicative information on dimensions and electrical power consumption per engine size. Note that the power consumption in normal operation is normally 80-85% of nominal power.



The picture shows an example of the water cleaning module.

Case studies

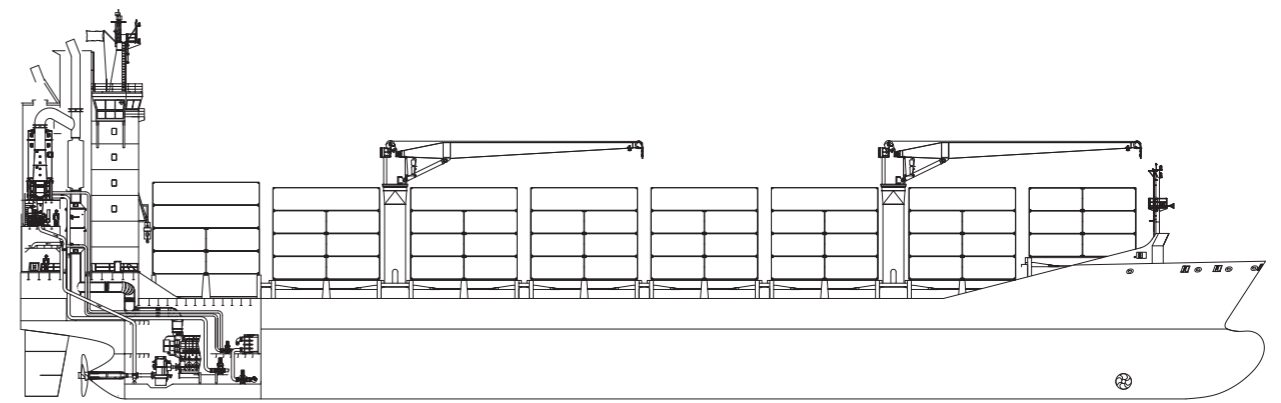
Alfa Laval has initiated case studies with several shipowners on different vessel types to determine the impact of PureSO_x on board their vessels.

Based on each ship's engines and operational profile, a PureSO_x system was selected. Detailed studies were carried out to ascertain the best way to fit the system into the vessel. Return on investment calculations were also carried out for different scenarios.

Alfa Laval has tools that help shipowners determine the feasibility of a PureSO_x system on board their vessels. Size, weight, required utilities, retrofit time, investment cost, operating profile and many other parameters are considered against the saving in fuel costs (operating on HFO instead of MGO). We can assist you in making such evaluations.

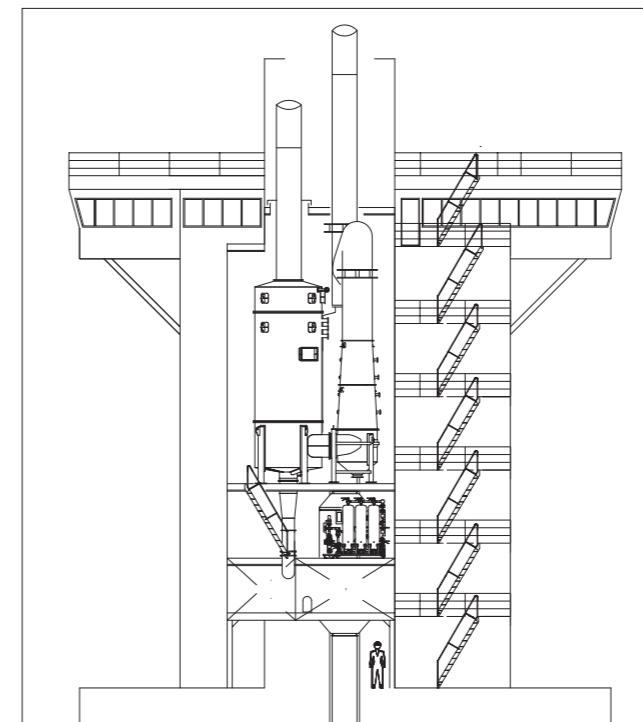


Installing PureSO_x on board the Ficaria Seaways.



Case 1: Container feeder

The container shipping sector in the Baltic and North Sea is highly competitive and fragmented. Both charterers and shipowners benefit from the installation of a scrubber, which lowers the operating cost of their vessels.



Location of the scrubber as viewed from the stern.

Summary

- Single inlet for the main engine.
- Hybrid system.
- Sailing 100% in ECA.
- Payback time of 1.9 years.

Ship's data	
DWT	9,300
TEU	800
Length (m)	140
Depth (m)	10
Breadth (m)	22
Number of main engines	1
Main engine power per engine (MW)	8
Main consumption (tonnes/year)	5,800

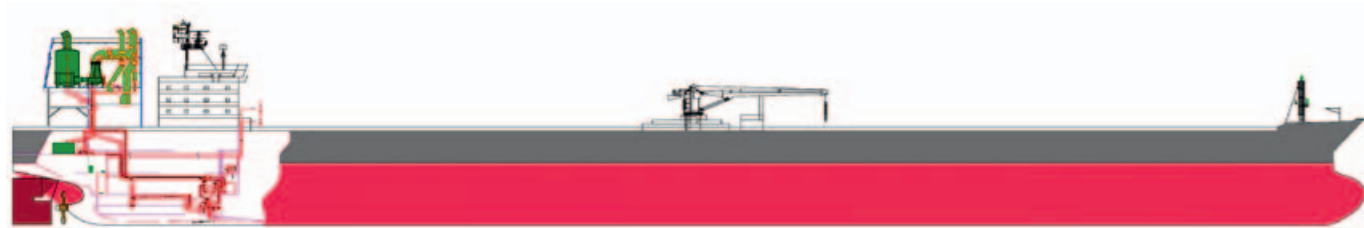
PureSO _x data	
Type	Hybrid, single inlet
Exhaust gas mass (tonnes/hour)	60
Width (m)	2.7
Height (m)	8.2
Weight (tonne)	9
Sludge production (tonnes/year)	1
Caustic soda consumption (tonnes/year)	31
Freshwater consumption (tonnes/year)	88

Economics	
Operational profile	
Operation area	Baltic/North sea
Hours at open sea per year	5,000
Hours in port per year	3,760

Costs based on HFO with PureSO _x per year	
Fuel (HFO)	€3,110,000
Operational costs PureSO _x	€109,000
Total cost of HFO operation	€3,219,000

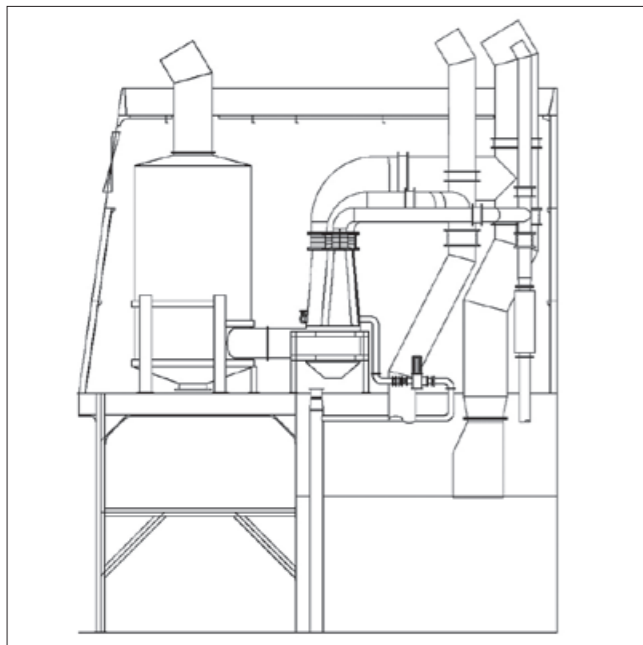
Costs based on MGO per year	
Fuel (MGO)	€4,490,000

Savings per year	
	€1,271,000



Case 2: Aframax tanker

In this case we evaluated the impact of a scrubber onboard an aframax tanker. As this study shows even when operating only 60% of the time in ECA, a scrubber is still an attractive solution.



Extending the funnel backwards facilitates placement of the Scrubber.

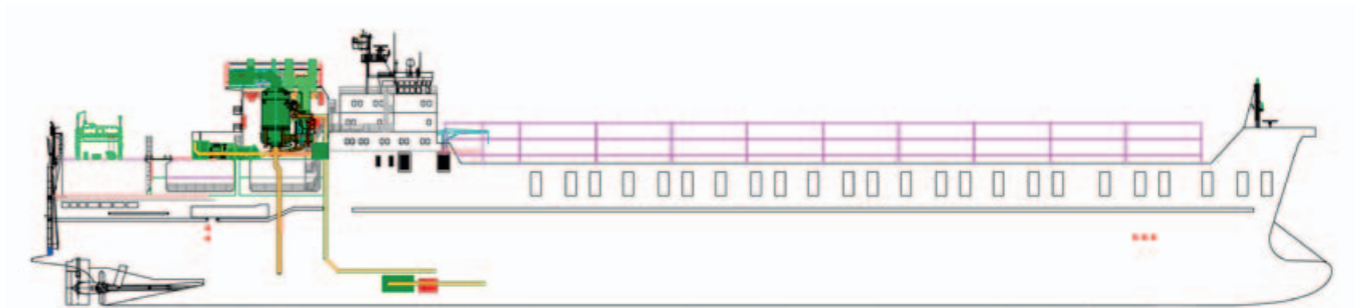
Summary

- Multiple inlet for main engine and auxiliary engines.
- Hybrid system.
- Sailing 60% in ECA.
- Payback time of 3 years.

Ship's data	
DWT	115,000
Tank Capacity (m ³)	130,000
Length (m)	250
Depth (m)	21
Breadth (m)	44
Number of main engines	1
Main engine power per engine (MW)	13.74
Main consumption (tonnes/year)	5,925
Number of auxiliary engines	3
Auxiliary power per engine (MW)	0.85
Aux. consumption (tonnes/year)	876

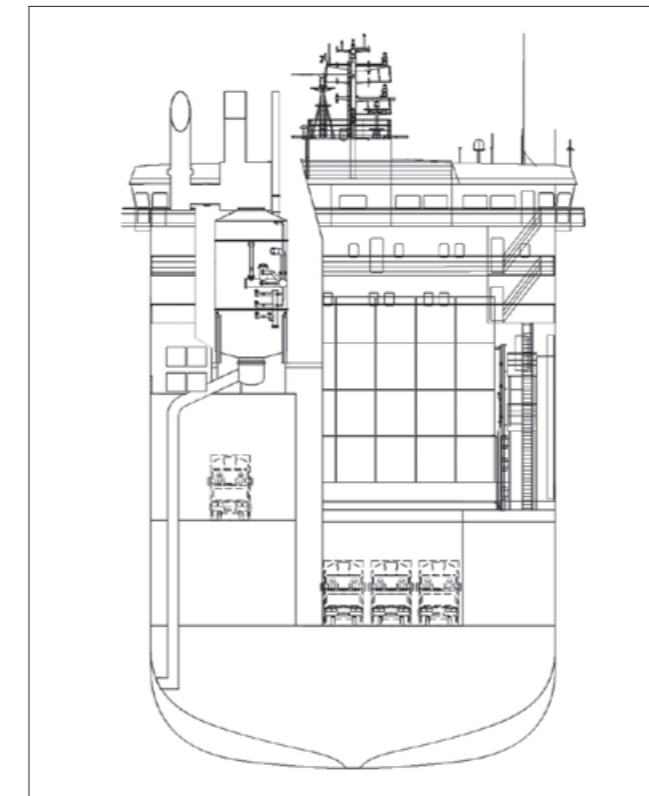
PureSO _x data	
Type	Hybrid, multiple inlet
Exhaust gas mass (tonnes/hour)	125
Width (m)	4.3
Height (m)	8.9
Weight (tonne)	24
Sludge production (tonnes/year)	6
Caustic soda consumption (tonnes/year)	246
Freshwater consumption (tonnes/year)	453

Economics	
Operational profile	
Operation area	Baltic/North sea
Hours at open sea per year	6,560
Hours in port per year	2,200
Costs based on HFO with PureSO _x per year	
Fuel (HFO)	€4,225,000
Operational costs PureSO _x	€290,000
Total cost of HFO operation	€4,515,000
Costs based on MGO per year	
Fuel (MGO)	€6,105,000
Savings per year	
	€1,590,000



Case 3: Ro-Ro ferry

Ro-Ro vessels have powerful engines, as time is crucial in this market. The payback time for this type of vessel is consequently very short.



The footprint of PureSO_x is minimized by extending the funnel sideways.

Summary

- Multiple inlet for main engines and auxiliary engines.
- Hybrid system.
- Sailing 100% in ECA.
- Payback time of 1.2 years.

Ship's data	
DWT	14,210
Gross tonnage	28,744
Length (m)	213
Breadth (m)	26.5
Number of main engines	4
Main engine power per engine (MW)	6.2
Main Consumption (tonnes/year)	17,534
Number of auxiliary engines	2
Aux. power (MW)	1.4
Aux. consumption (tonnes/year)	712

PureSO _x data	
Type	Hybrid, multiple inlet
Exhaust gas mass (tonnes/hour)	131
Width (m)	4.5
Height (m)	9.5
Weight (tonne)	24
Sludge production (tonnes/year)	14
Caustic soda consumption (tonnes/year)	570
Freshwater consumption (tonnes/year)	1,492

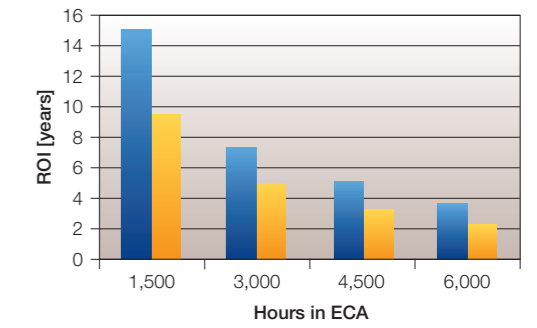
Economics	
Operational profile	
Operation area	Baltic/North sea
Hours at open sea per year	6,200
Hours in port per year	2,560
Costs based on HFO with PureSO _x per year	
Fuel (HFO)	€9,732,000
Operational costs PureSO _x	€336,000
Total cost of HFO operation	€10,068,000
Costs based on MGO per year	
Fuel (MGO)	€14,062,000
Savings per year	
	€3,994,000



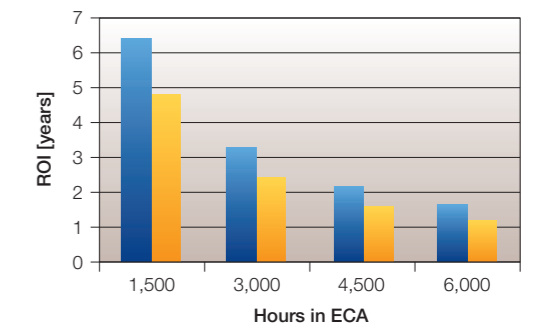
Return on investment

The tables show typical payback times for PureSO_x.

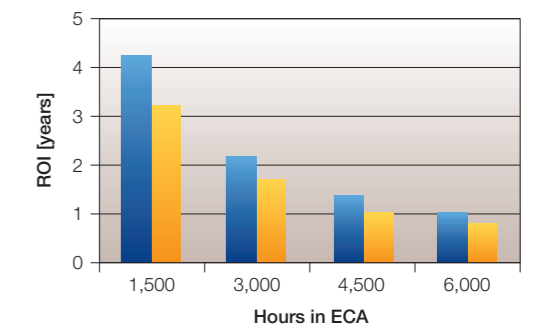
4 MW engine



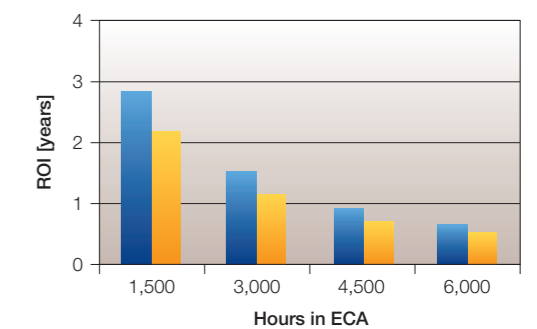
10 MW engine



22 MW engine



44 MW engine



■ Retrofit
■ New build

Alfa Laval in brief

Alfa Laval is a leading global provider of specialized products and engineered solutions.

Our equipment, systems and services are dedicated to helping customers to optimize the performance of their processes. Time and time again. We help our customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuffs, starch and pharmaceuticals. Our worldwide organization works closely with customers in almost 100 countries to help them stay ahead.

How to contact Alfa Laval

Contact details for all countries are continually updated on our web site. Please visit www.alfalaval.com or www.aalborg-industries.com to access the information.

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