

Staying ahead in SOx compliance

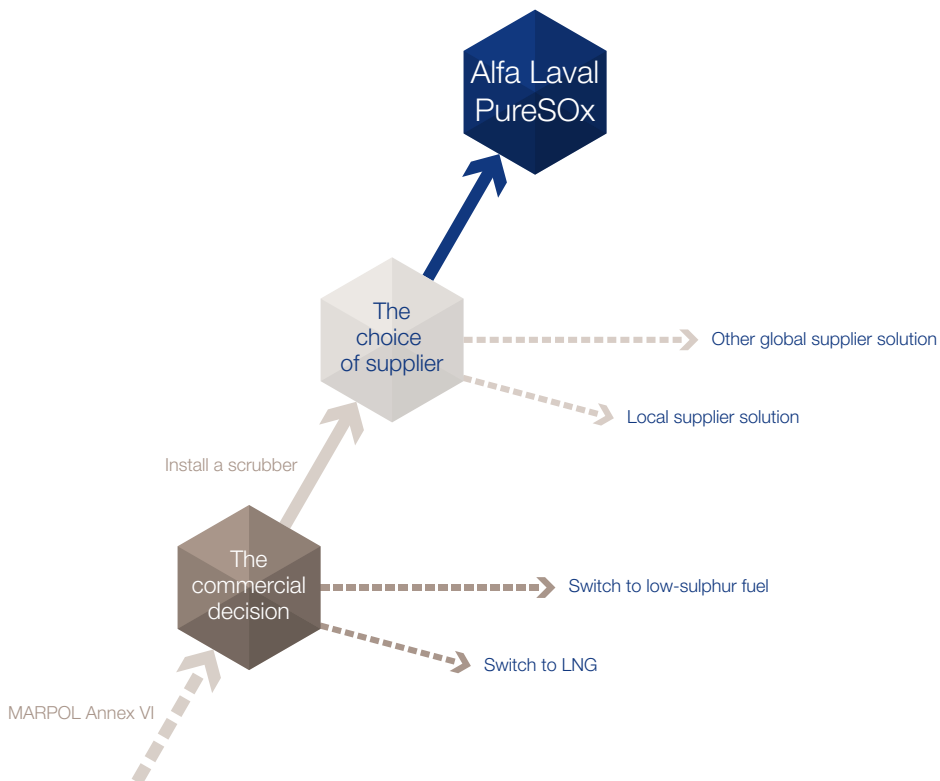
A guide to SOx abatement alternatives, scrubbers and suppliers



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Think ahead

Starting in 2020, all vessels must comply with global sulphur limits established in MARPOL Annex VI. Making the right compliance choices now can keep you a step ahead.



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Don't just comply

Environmental legislation is having an acute effect on today's marine industry. For ship owners and ship operators, it is an additional constraint on an already difficult business – especially when it forces a change in the equipment on board.

With respect to equipment, however, the regulation of sulphur emissions by MARPOL Annex VI is somewhat different. While all vessels must comply, there are multiple strategies available for doing so. This booklet's first aim is to help you understand them.

Its further aim is to explore one of those strategies – SOx scrubbers – in detail. Scrubbers are becoming a familiar presence in the marine industry, as they provide an excellent balance of compliance security and operating economy. Yet scrubber solutions are far from the same. The technology and supplier you choose can make the difference between bare-minimum compliance and truly staying ahead.

— be a step ahead

Alfa Laval's own capabilities and an overview of the Alfa Laval PureSOx system are presented in a separate chapter.

The final pages include a convenient guide and checklist to assist you in supplier evaluations, as well as a list of resources for further reading. With this booklet in hand, you will be able to make informed and confident decisions that keep you at the forefront.

Best regards,

Erik Haveman

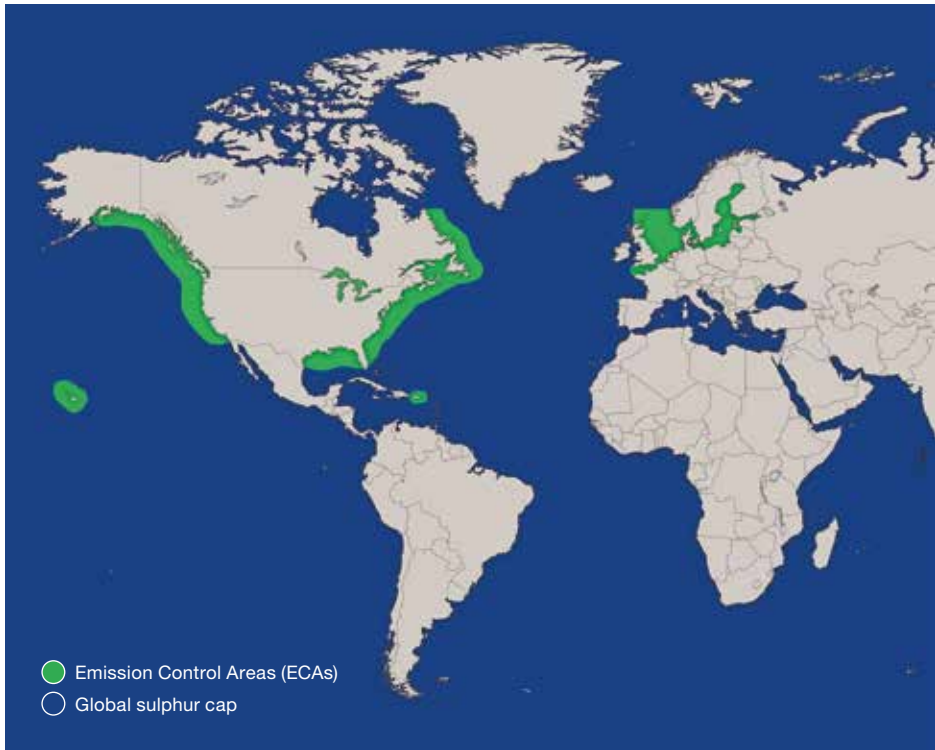
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The commercial decision

Emission limits are having a strong effect on the marine industry as ship owners and ship operators choose different strategies for compliance. Your own choice can be one that puts you at the mercy of higher fuel prices, or one that retains your competitive power.





MARPOL Annex VI and SO_x limits

Vessel emissions – including those related to sulphur – are governed by MARPOL Annex VI, which first entered into force in May 2005. IMO has adopted subsequent revisions of Annex VI to progressively reduce the maximum allowed sulphur content of marine fuels.

However, IMO has also approved the use of higher-sulphur fuels with exhaust gas scrubbers that remove a corresponding amount of sulphur oxides, or SO_x. This is referred to as an “equivalence” in IMO terminology.

SO_x is a collective term for sulphur dioxide (SO₂) and sulphur trioxide



As of January 2015,
the limit applicable
in ECAs is

0.1% S

As of January 2020, the
global limit applicable
outside of ECAs is

0.5% S

(SO₃). Hazardous to the environment and to human health, SO_x is produced during the combustion of fuel, along with harmful particulate matter (PM) in the form of soot and ash.

Additional PM is formed when the SO_x reaches the atmosphere and forms small aerosol compounds,

which is the reason why SO_x and PM fall under the same heading in Annex VI.

The higher the fuel sulphur content, the greater the SO_x content in the exhaust gas and the level of PM formation.

The global cap and ECAs

MARPOL Annex VI establishes the regulation of a global sulphur cap, as well as stricter regulation in Emission Control Areas (ECAs).

As of January 2020, the existing global cap will be reduced from 3.5%S to 0.5%S. This was decided by the IMO Marine Environment Protection Committee (MEPC) in October 2016.

The sulphur limit in ECAs, applicable since January 2015, is 0.1%S. Any party to MARPOL Annex VI can apply to become an ECA, with the time from application to enforcement taking about 18 months.

It is also worth noting that there are ports around the world that have chosen to establish their own sulphur limits outside of those set by MARPOL Annex VI. In some cases, these limits are stricter than the global cap.





What choices does the legislation imply?

Needless to say, the heavy fuel oil (HFO) in popular use today has a sulphur content well above the limits established in MARPOL Annex VI – at present the world average is 2.4%S. With this in mind, current regulations leave you as a ship owner or operator with three basic options going forward:

- Switch to liquefied natural gas (LNG) or another liquefied gas
- Switch to a low-sulphur fuel
- Install a SO_x scrubber and continue using HFO

This list is deceptively simple, however. Each of the choices has major implications, both for your ease of doing business and for your short-term and long-term profitability. These implications are explored in the following sections.



Switching to LNG

In emission terms, using LNG rather than HFO is an elegant solution. Because LNG contains absolutely no sulphur, it eliminates the problem of SO_x altogether. The issue lies not in the result, but rather in the complexity of making the change.

LNG will put you in compliance with MARPOL Annex VI, but in order to run on LNG with an existing vessel, you will need a retrofit that is complicated and expensive. Not all engines can be modified for LNG use, and cargo or passenger space may have to be reduced in order to

accommodate the much larger fuel tanks. As a result, LNG is an option most feasible for newbuilds.

At present, the prospects for LNG remain somewhat uncertain. The LNG infrastructure is still underdeveloped, even as LNG is being selected for an increasing range of newbuilds. LNG will undoubtedly continue to grow, and most likely it will be a significant fuel by 2030. Nonetheless, its cost development and availability are difficult to project.

Switching to a low-sulphur fuel

By far the easiest choice is to operate on a distillate fuel like MGO rather than HFO. This will be an interim choice for some while evaluating other options, whereas for others it will be a long-term strategy.

The choice is not entirely problem-free, due to the differences in properties between low-sulphur fuels and HFO. It may be necessary to replace older pumps and other equipment to prevent leakage and sticking, or to invest in a more modern booster system designed to handle changeover between fuels of different temperatures and viscosities. Without proper automation and cooling, the fuel changeover process becomes difficult and hazardous, which may lead to critical engine stops.

The financial implications of choosing a low-sulphur fuel will depend in part on whether you view it as a temporary solution or as a permanent route to compliance. Since the cost of low-sulphur fuels is higher than that of HFO, significant usage will increase your fuel costs – thus changing the conditions for your business.

In short, switching to low-sulphur fuels involves a small initial investment and requires little immediate thought. It will, however, reduce your long-term competitive power. If your competitors continue operating on HFO, your own choice of fuel may give them a chance to pull ahead.





Installing a SOx scrubber

As previously described, IMO has approved the use of higher-sulphur fuels with exhaust gas scrubbers, globally and in ECAs, so long as the scrubbers remove an amount of SOx equivalent to the MARPOL Annex VI requirements. The ability of scrubbers to do this has been firmly demonstrated.

A SOx scrubber is a substantial investment requiring a significant space on board, as well as a number of weeks to retrofit. However, with a SOx scrubber installed you can continue operating on HFO, enjoying the best possible fuel economy. Regardless whether you need to comply with the global sulphur cap or stricter ECA limits, your fuel savings will be measurable – and substantial.

Compared to competitors who rely on low-sulphur fuel, you will have a long-term cost advantage that can be used to reduce your prices or to increase your operating profits.

Scrubbers are simple in principle and have been used in industrial applications for many years. Though they must be optimized for use at sea, they are proven in the marine environment and have been an integral component of inert gas production systems for decades. What matters most is not your choice of an open-loop, closed-loop or hybrid scrubber arrangement, but rather the choice of an experienced scrubber supplier.

Will the fuel market change?

Fuel economy is the incentive for using anything other than low-sulphur fuels to comply with MARPOL Annex VI. So long as there are cheaper fuel alternatives, those alternatives will have a strong business case.

Of course, the future price of a given fuel is difficult to predict. The price of LNG, for example, might become lower as the LNG infrastructure expands. Likewise, no one can anticipate the exact price of low-sulphur fuels and HFO in the coming years.

However, a continued difference in price between low-sulphur fuels and HFO is likely. So long as it remains in common use worldwide, a residual fuel like HFO will always be a cheaper alternative. This price differential is what justifies the installation of a scrubber – and its size determines your time to payback and profit.

One thing is certain: the sooner you choose a scrubber, the greater your potential long-term savings will be.



Does your business model make a difference?

Installing a SOx scrubber lets you continue using HFO, which means fuel cost savings. Directly or indirectly, those savings can be used to strengthen your business – no matter what your business model.

For owner-operators

If you both own and operate your vessel, you pay for your own fuel. This makes the case for installing a scrubber relatively simple. You save money by purchasing HFO rather than a low-sulphur fuel, which is money you can reinvest in your business or pocket as profit.

For owners of chartered vessels

If you charter your vessel to others, it is usually the

company operating the vessel that pays for the fuel. However, a scrubber will let you offer a stronger business case than competitors reliant on more expensive fuels. Those who charter your vessel will be able to keep their own prices down, which will allow them to gain business over other shippers.

Already, there are examples where the projected difference between HFO and low-sulphur fuels is tipping the competitive balance in contract negotiations.



The time to choose is now

A “wait-and-see” approach to SOx abatement – in the hopes of a drop in low-sulphur fuel prices or a sudden improvement in the LNG infrastructure – is no doubt an option. What is certain, however, is that choosing to invest in a SOx scrubber means immediate payback in terms of fuel-related operating costs.

The longer you delay your choice, the more difficult it may be to

implement when you make it. In addition to MARPOL Annex VI, other environmental regulations are necessitating new equipment on board. Shipyard availability, as well as the number of suppliers who can deliver a scrubber on time, may thus be limited in the future.

By delaying your decision, you may be committing to expensive fuel for a long time to come.

The choice of scrubber

Choosing a scrubber is the economical way to meet SOx emission limits. But the choice is a long-term one, and there are differences between scrubber solutions. Your priorities and sailing profile are both important to consider.



Scrubbers at sea

Scrubbers are emission control devices that remove unwanted SO_x and particulates from exhaust gas, preventing them from entering the atmosphere. In most cases, as suggested by the name, the pollutants are literally “washed” out of the exhaust gas.

While scrubbers have a longer history of use in industrial applications on land, they are not new to the marine industry.

For example, they are an integral component of inert gas production systems, which generate cargo-stabilizing inert gas for oil and chemical tankers and inert gas for gas freeing of LNG cargo tanks. While scrubbers have a longer history of use in industrial applications on land, they are not new to the marine industry.



Scrubber types

Two general categories of scrubber exist: wet and dry. Both have been shown to meet the requirements of MARPOL Annex VI, but wet scrubbers remain the dominant type within the marine industry.

Wet scrubbers

Wet scrubbers wash the exhaust gas stream by forcing it into contact with a liquid. In the case of marine SOx scrubbers, this liquid may be the readily available seawater, which is naturally alkaline, or desalinated circulation water mixed with an alkaline additive (usually caustic soda). The SOx compounds are absorbed and converted into harmless substances, while much of the particulate matter is trapped in the liquid and thereby prevented from entering the atmosphere.

Dry scrubbers

Dry scrubbers force the exhaust gas through a dry bed of granulated calcium hydroxide. Although simple to install and operate, they are less common in the marine industry. This is partly due to their high rate of granulate consumption, which may approach 20 tonnes per day for a 20 MW engine.* In addition to the fresh granulate, the used granulate must be stored on board prior to onshore disposal, which means considerable weight and large space requirements.

* Source: "Understanding exhaust gas treatment systems: guidance for shipowners and operators", Lloyd's Register, June 2012.



Scrubber compliance schemes

Scrubbers are an IMO-approved equivalent to low-sulphur fuels in complying with MARPOL Annex VI. Their compliance can be demonstrated according to two schemes:

Scheme A

The performance of the installed scrubber system is initially verified and certified. This is followed by periodic surveys, which can involve the use of a continuous exhaust gas monitoring system. If a monitoring system is not installed, daily spot checks are recommended.

Scheme B

The performance of the installed scrubber system is not verified. Instead, emissions are continuously monitored to show that the system is in compliance. Daily checks of key operating parameters are also required, although as these are a part of the control system, they are monitored continuously in practice.

Since emission checks are required with either scheme, most vessels opt for Scheme B in order to avoid the added expense of certification. However, continuous monitoring places high requirements on sensors, instrumentation and data storage systems, which must therefore be robust and reliable.

The environmental impact of scrubbers

Marine SOx scrubbers are generally of the “wet” type. This means they scrub the exhaust gas either with seawater or with desalinated circulation water with an alkaline additive. In the process, the SOx is first dissolved and ionized, then oxidized into sulphates. Sulphates are a natural part of both seawater and aquatic organisms, which means they are harmless to the environment.

In closed-loop operation, the water is recirculated and the compounds accumulated in it are removed by a water cleaning unit. This forms a sludge that is deposited on shore like any other vessel sludge, while only clean water and sulphate salts with a neutral pH value go overboard.

In terms of energy and CO₂ footprint, the use of SOx scrubbers has advantages over distillates in a global perspective. At the refinery, the desulphurization of HFO is a very energy-intensive process that increases CO₂ production substantially.

Operating arrangements

Wet SO_x scrubber systems can be configured in three different operating arrangements. They can be prepared for open-loop scrubbing with seawater, for closed-loop scrubbing with circulation water or as hybrid systems, capable of operating with either seawater or circulation water.

Open-loop scrubbing

A scrubber in an open-loop arrangement scrubs the exhaust gas directly with seawater, which is then legally discharged back into the sea.

This involves the least amount of equipment, which means a lower investment cost and simpler installation. Likewise, it means the lowest possible operating cost, since there are no consumables.

However, an open-loop scrubber system may not perform adequately in low-alkalinity waters, such as the northern waters of the Baltic Sea (see fact box on page 27). In addition, its use may be limited by local discharge legislation.

Closed-loop scrubbing

The performance and discharge issues associated with open-loop scrubbing are avoided with a closed-loop arrangement. In closed-loop scrubbing, the scrubber water is dosed with an alkaline additive (usually caustic soda) and recirculated. Because recirculation leads to a build-up

of impurities and diminished scrubbing effect, a portion of the circulation water (bleed-off stream) is periodically cleaned, discharged and replaced with desalinated water to retain capacity.

Because an additive controls the water alkalinity within the scrubber, the seawater alkalinity is irrelevant. Moreover, discharge into the sea can be avoided altogether for long periods of time. The drawbacks are additional equipment, which includes the water cleaning unit, and a higher operating cost due to the need for desalinated water and additive.

Hybrid scrubbing

A hybrid arrangement offers an ideal compromise between the cost efficiency of open-loop scrubbing and the operational security of closed-loop scrubbing. In a hybrid scrubber system, both open-loop and closed-loop modes are available, ideally at the push of a button.

Simply put, a hybrid system operates in open-loop mode whenever possible, which reduces its operating costs. Whenever demanded, it can nonetheless switch into closed-loop mode. This allows continued operation on HFO while respecting local opposition to open-loop water discharge, or in compliance with local regulations that forbid the discharge of wash water altogether.

Alkalinity and the Baltic Sea

Seawater alkalinity has a proportional effect on a scrubber's cleaning ability. The lower the alkalinity, the lower the cleaning capacity. In the Baltic Sea, the alkalinity of the water gets lower as you sail northward.

How far north you can sail before open-loop scrubbing becomes ineffective depends on the time of year, but also on the size of your system. Increasing your scrubber size will extend its seawater range, thus reducing your consumption of desalinated

water and alkaline additive. But this must be weighed against the added equipment and installation cost.

In general, extending seawater operation pays off if you sail in the Baltic Sea on a regular basis.



Scrubber designs

The main component of a wet SO_x scrubber system is the scrubber itself. Different scrubber designs are possible, with different placements of the jet and absorber sections. Their characteristics must be weighed against the design of the vessel as a whole.

Split designs

Most wet SO_x scrubbers have a split design, which means that the jet and absorber sections are physically independent from one another. The absorber section forms the main bulk, while the jet section is a smaller additional unit.

Because it has two vertical sections, a split design has a larger footprint. Yet it is also the simplest design. The connection between the sections forms a natural water trap that protects the engine from water backflow, and fewer additional components are needed in the lower part of the vessel.

Inline designs

Scrubbers can also be built with an inline design, in which the absorber section is placed directly atop the jet section. In other words, the two sections are integrated without any intermediate connection.

This is especially appealing for vessels with difficult space constraints or stability issues, such as cruise ships and RoPax vessels. However, an inline design is not only taller, but also more complex. For example, careful attention must be paid to creating a safe water trap in order to protect the engine. Moreover, the scrubber will experience greater material stresses, as it will be cooled and heated with every start and stop.

Configuration criteria

Configuring a SOx scrubber is a complex process. The choice of operating arrangement and scrubber design depends on both your vessel's sailing profile and its physical constraints.

Choosing an operating arrangement

While the lower initial investment of an open-loop arrangement is tempting, there are good reasons for considering a closed-loop or hybrid arrangement. One is the amount of time you spend in low-alkalinity waters like the Baltic Sea (see fact box on page 27). The other is the ability to use the scrubber in areas where open-loop discharge – or even any discharge – is discouraged or prohibited.

In some US states, zero-discharge regulations have already taken effect. Similar laws are being considered for heavily trafficked ports in Europe. If the latter become a reality, there is a good chance that you will need the ability to operate your SOx scrubber in a closed loop.

Depending on your requirements and your supplier's capabilities, it may be possible to install an open-loop scrubber system that is prepared for later conversion to a hybrid version. Your supplier may also be able to reduce cost and space requirements by supplying a multiple-inlet scrubber system, which will allow one scrubber to handle exhaust gas from several sources.

Choosing a scrubber design

When it comes to the scrubber itself, it is important to remember that the scrubber's design affects the system as a whole. Not all components are placed within the ship's funnel.

While an inline design demands less space for a single scrubber, it does involve additional considerations. So while it can solve challenging space and stability issues on certain vessels, an inline design should not be seen as a default. Even on cruise ships and RoPax vessels, a split design may prove to be the better choice.



Scrubber optimization and vital equipment

As mentioned previously, scrubbers are simple in principle and proven to work at sea. However, it takes considerable knowledge to optimize their function – especially in the marine environment. Only a handful of suppliers have the breadth and experience required, as will be discussed later in more detail.

Besides the overall optimization of your SOx scrubber system, there are individual equipment aspects that are vital to consider. One of these is the quality and robustness of the sensors and data systems used to verify compliance. To put

the matter bluntly: if you cannot prove your compliance, you are not in compliance.

Another critical aspect is the water cleaning equipment used in a closed-loop arrangement or by a hybrid system operating in closed-loop mode. Here there is no substitute for a centrifugal separator, which contributes to a compact installation and is more reliable than other existing alternatives. In rough seas, a centrifugal separator is the only solution that will remain unaffected by pitch and roll.

The choice of scrubber supplier

For smooth installation and reliable compliance, you need not only the right scrubber system, but also the right supplier. Your supplier's capabilities – and ability to work with others – have a profound effect on the end result.





Scrubbers from local suppliers

There is naturally no requirement that you purchase your SO_x scrubber from a global or even a large supplier. As long as your scrubber complies reliably with MARPOL Annex VI, it can be built by virtually anyone. Certainly there are many suppliers, including local suppliers without a marine background, who are eager to enter the market.

It is important to remember, however, that these suppliers have little experience with class rules and marine regulations. Likewise, they are limited in the assurances they can offer.

On the equipment side, local suppliers may lack specific experience and developmental resources, especially when it comes to water cleaning. A local supplier who

wishes to create a reliable water cleaning unit, let alone a complete scrubber system involving many types of equipment, faces a steep learning curve.

On the delivery side, local suppliers may lack the manufacturing and logistical infrastructure to deliver on time. If your supplier is unable to equip your shipyard during the scheduled slot, you will incur a great deal of additional expense.

Finally, local suppliers can offer only a limited scope of service. If your scrubber cannot perform as required by law, you may be subject to fines or stuck in port while waiting for parts or repairs. At the very least, you may be forced to switch to a low-sulphur fuel – which would defeat the purpose of your investment.





Scrubbers from global suppliers

If you purchase your SOx scrubber from a global supplier, you can place higher expectations on its performance, its reliability and the degree of support that follows with it. As there are a number of major actors providing scrubbers to the marine industry, all with solutions that are compliant with MARPOL Annex VI, there is an ample range of more secure choices.

These suppliers have a much broader base of experience, if not with scrubbers specifically than at least with the supply of large-scale marine solutions. With their more substantial resources, they will be better equipped to help you select a scrubber and adapt it to your specific vessel – and to support it in years to come.

Nevertheless, there are important differences even among global suppliers. Some have a great deal of marine background, but little direct experience with scrubbers. Some have supplied scrubbers for auxiliary engines, but lack experience with main engines, which have greater safety requirements, higher power and a higher variable load.

Even among global organizations, there are substantial differences in the extent of their networks and the speed with which they can deliver a scrubber or provide service for it.

The remaining sections of this chapter highlight key points to consider in evaluating any supplier, local or global.



Access to core expertise

As previously discussed, scrubbers as a whole are not new to the marine industry. However, the base of long-term experience with scrubbers is limited to a handful of marine suppliers.

Even suppliers who have done significant work with scrubbers may lack in-house access to key equipment expertise. This is especially true when it comes to water cleaning, which is a critical function in both closed-loop and hybrid configurations.

For a company with limited experience in separation, the path to a scrubber-optimized water cleaning unit may be long and difficult.

Also important to consider is a supplier's ability to integrate the scrubber into the vessel as a whole – which includes integration with vessel control systems. Key operations should offer “one-button” simplicity, operating transitions should be automated and engine operation should be kept independent from the scrubber's. A supplier who has worked with a broader range of marine equipment may have stronger abilities in this regard.



Reference breadth

References are critical in evaluating any technology, but especially when that technology is used for legislative compliance. Some of the SOx scrubbers available today are largely untested in real-life marine operation. Others are proven, but only within a limited operating range. For example, they may be in use with auxiliary engines but not main engines.

A supplier's reference list should be not only long, but also comprehensive. Ideally, it should reflect compatibility with engines from all major manufacturers, as well as a good balance of installations covering both main and auxiliary engines – from single-engine

installations of a few MW to multiple-engine installations larger than 60 MW.

It can also be important to make sure a supplier is familiar with the range of regulations facing vessels operating in different regions. For example, some technologies can ensure compliance with the global sulphur cap, but may be unsuitable for stricter limits in ECAs and vice versa.

Another assurance to look for is the presence of repeat orders, especially from customers who have had their scrubbers in use. The decision to purchase again, based on successful operation at sea, is a definitive seal of approval.

Referenced technologies

A supplier's reference list cannot always be taken at face value. Rather, it must be examined critically. The simple reason is that most supplier reference lists comprise a range of different technological platforms.

Many suppliers have begun working with one scrubber technology, then have switched to another when the first proved difficult to implement or optimize. Others have developed an in-house technology for open-loop systems, for example, but have purchased another externally for closed-loop systems. As players have entered and left the market, technologies have frequently been abandoned or switched hands.

The longer a supplier has owned and optimized its technology, the stronger that technology is likely to be. If all of a supplier's SO_x scrubber installations – including trial installations – are still operating to the customer's satisfaction, it is an indication of a sound technological foundation and ongoing optimization.





Delivery capabilities

Whatever scrubber system you choose, your supplier must be able to deliver it to your shipyard within the negotiated timeslot. If the window of opportunity is missed, you are the one who will pay the price – both figuratively and literally.

This issue will likely become more critical as the 2020 global sulphur cap approaches, with an increasing number of scrubber retrofits making it more difficult to obtain equipment and shipyard time. But it may also be influenced by a general rise in fuel prices or an increased gap between HFO and low-sulphur alternatives, which would cause many to rethink their reliance on expensive fuels. Even other concerns – such as an anticipated wave of ballast water treatment system retrofits – may limit shipyard slots in the coming years.

For this reason, it is important to assess a supplier's manufacturing capacity, delivery network and logistical accuracy. Smart delivery solutions and any planning or commissioning work that can be handled on board, rather than at the shipyard, can make a substantial difference in the amount of time out of service. Ideally, the scrubber installation can be limited to just a few weeks.

Project coordination

The process of getting a scrubber on board is generally one involving several parties. In addition to the company supplying the scrubber equipment, you will most likely work with an engineering company to finalize the design for placement on your vessel. Most certainly, you will work closely with the chosen shipyard.

The smooth cooperation between all parties, each of which has its own area of responsibility, is vital. While you as the purchaser are the main interface, your supplier can facilitate the others' work.

This results in a more coordinated, efficient and successful process.

Above all, your supplier should provide thorough documentation that goes beyond the scrubber drawings. This should include design guidelines and other documents to assist the engineering company, as well as instructions and project-specific support for the shipyard. Clear checklists are advantageous, both in preparing the installation work and in verifying that it has been carried out properly.





Long-term service and support

Your SOx scrubber is not a temporary solution, but rather one intended to last for the lifetime of your vessel. In light of this, it is vital to choose a stable supplier with a strong global network. Worldwide, you should be able to count not just on a handful of representatives, but also on a comprehensive and experienced service organization.

If your scrubber is appropriately designed, well installed and properly commissioned, you can expect it to operate reliably day after day. Nonetheless, you will want 24/7 access to your supplier's services – anywhere in the world – in the unlikely event of a system failure. Over time, you will also want access to expertise for ongoing optimization.



Openness of approach

The dialogue you have with your supplier is just as important as any technical consideration.

If possible, ask potential suppliers if you can view their scrubber solutions in full-scale operation, either on board or elsewhere. This will create a hands-on opportunity in which to discuss the pros and cons of the scrubber technology – where potential issues and solutions for your own vessel can be examined directly.





Alfa Laval PureSOx

This section provides details about Alfa Laval PureSOx, the SOx scrubber system developed and supplied by Alfa Laval. Of the many scrubber technologies on the market, PureSOx is among the most established and widely chosen.

PureSOx in overview

Alfa Laval PureSOx is a scrubber system specifically designed for marine SOx abatement. At sea since 2009 and launched commercially in 2012, it has been continuously developed and optimized over time. The technological foundation for PureSOx, however, has always been the same.

Confirmed performance

PureSOx has been shown to reliably remove more than 98% of the SOx content in exhaust gas, as well as up to 80% of the particulate matter (PM). This exceeds both the global cap and ECA requirements set by IMO in MARPOL Annex VI. Even during periods of rapid change in engine load, SOx levels are kept well within emission limits, as has been demonstrated during thousands of hours at sea.

Thorough flexibility

PureSOx is a complete scrubber system for both global and ECA use. It can be configured to match not only your sailing profile, but also the physical constraints of your vessel. Open-loop, closed-loop and hybrid arrangements are available, as well as the possibility of multiple exhaust gas inlets.

Extensive references

PureSOx has a substantial reference list, comprising more references than any other single SOx scrubber technology. Among them are some of the world's largest scrubber installations, a broad range of vessel types and repeat orders from satisfied major customers.

All PureSOx systems ever supplied are still in use and operating in compliance with MARPOL Annex VI limits.

Comprehensive strengths

PureSOx builds on Alfa Laval's full century of maritime experience, as well as core Alfa Laval expertise. Alfa Laval possesses over 50 years of specific experience with marine scrubbers, as well a world-leading strengths in centrifugal separation.

This chapter provides a complete introduction to the PureSOx offering, including a summary of the support, documentation and resources offered by Alfa Laval as a supplier.

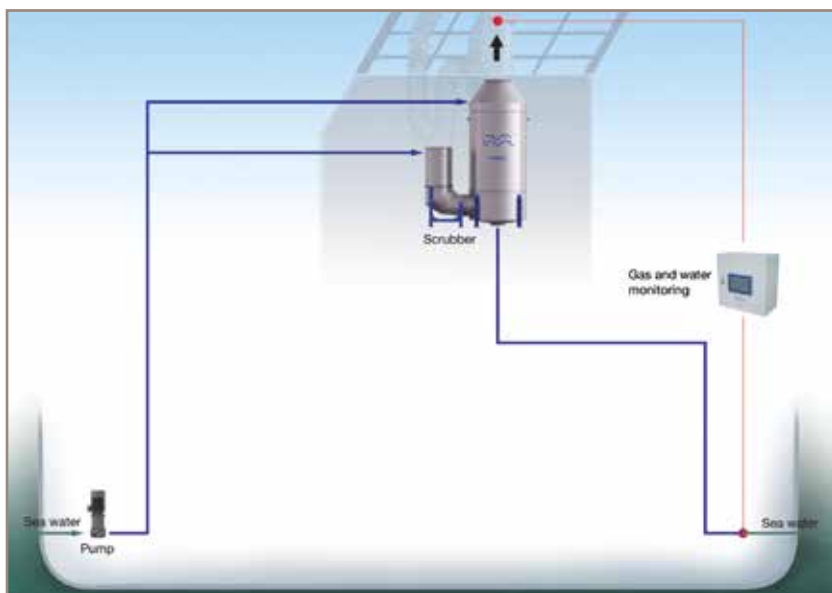




PureSOx operating arrangements

PureSOx is available in open-loop and closed-loop arrangements, as well as a hybrid arrangement with both open-loop and closed-loop modes. Your priorities and area of operation determine which one is most appropriate for your vessel (see *Configuration criteria* on page 30).

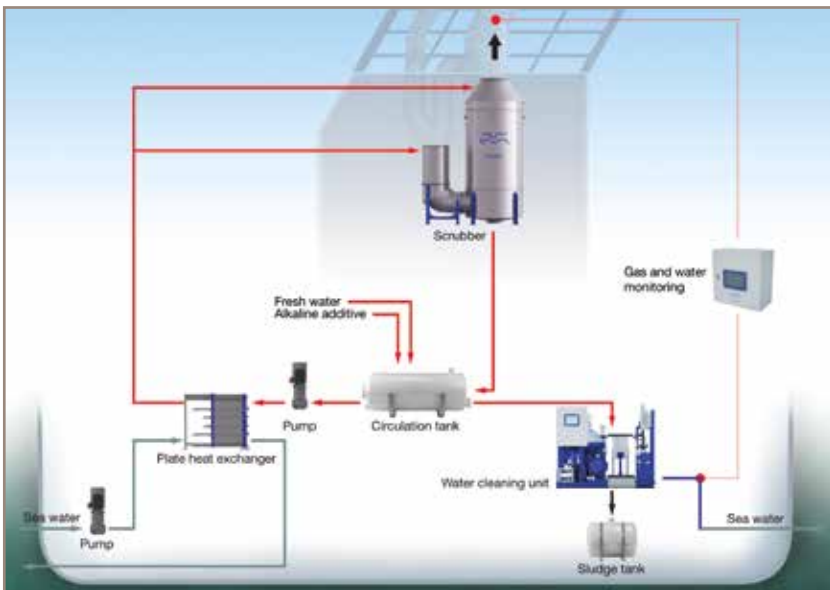
The following are schematic representations, intended to show the operating principles of each configuration. The actual system layout for an individual vessel may vary.



Open-loop arrangement

Seawater is used to scrub the exhaust gas and remove SO_x. After passing through PureSOx, the water is discharged back into the sea in accordance with legislation.

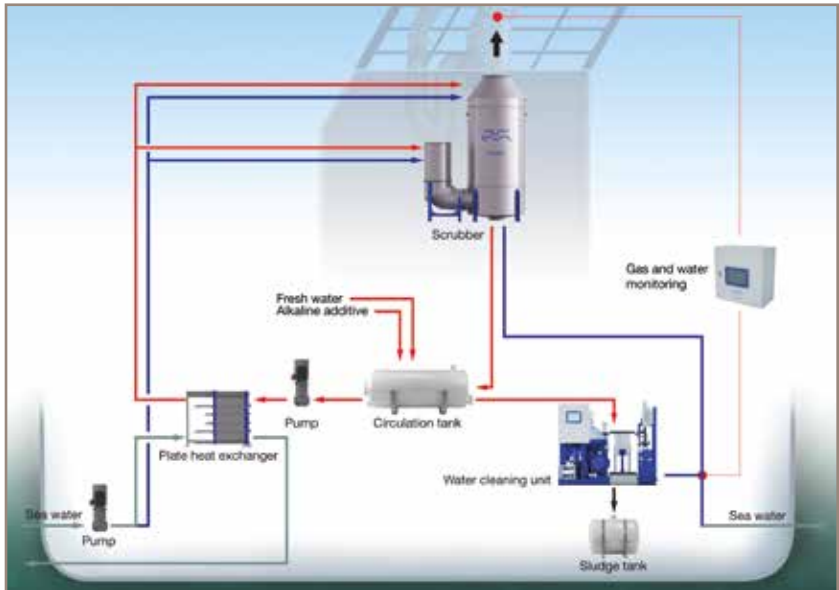
- + Least equipment, investment and operating cost
- Use may be limited by low alkalinity or local water discharge regulations



Closed-loop arrangement

The scrubber water is dosed with an alkaline additive and recirculated. As it becomes dirty, the circulation water is cleaned, discharged and replenished to retain scrubber capacity.

- + Possible to operate anywhere and at any time
- Higher operating cost due to desalinated water and alkaline additive

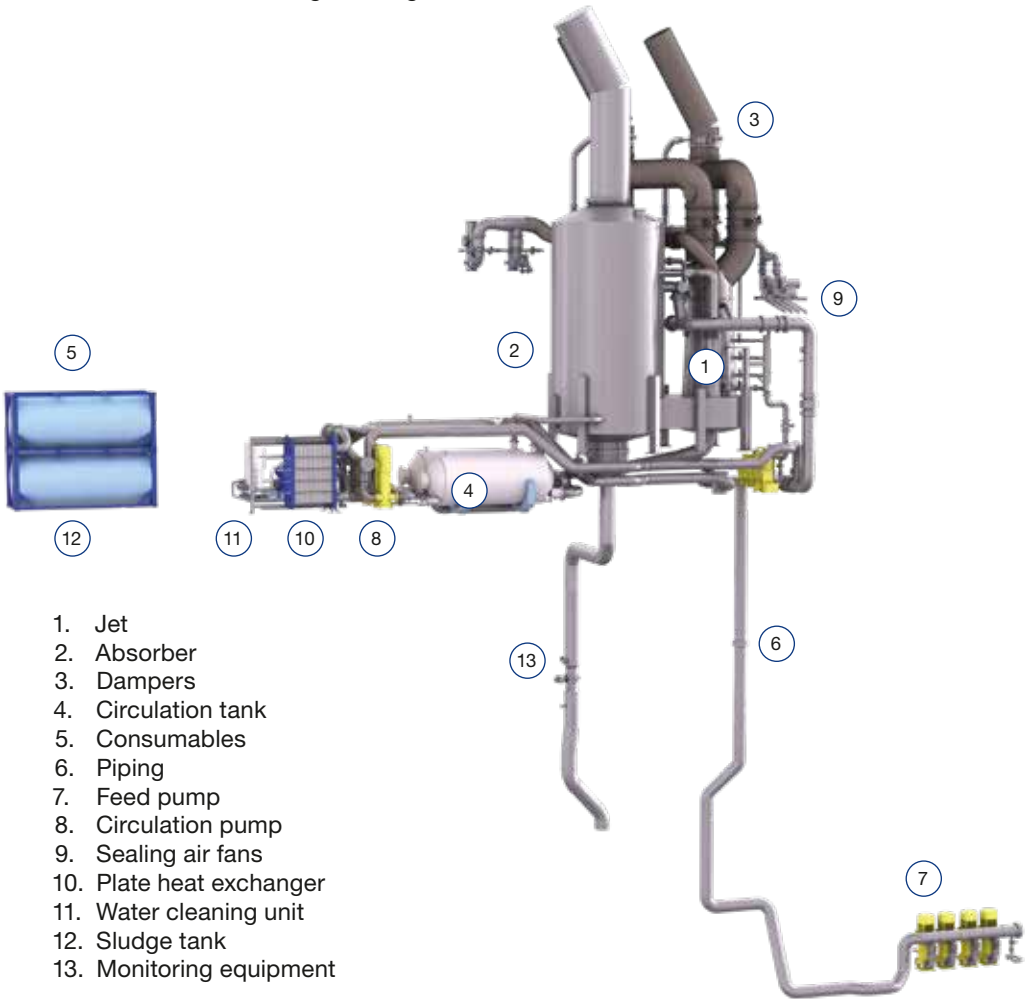


Hybrid arrangement

Both open-loop and closed-loop modes are available. Switching modes takes less than a minute and is done at the push of a button.

- + Open-loop operation reduces costs whenever possible
- + Closed-loop operation is available when demanded by local water discharge regulations

Shown here is the hybrid configuration for the Spliethoff Plyca, which is a 28 MW installation involving four engines.



1. Jet
2. Absorber
3. Dampers
4. Circulation tank
5. Consumables
6. Piping
7. Feed pump
8. Circulation pump
9. Sealing air fans
10. Plate heat exchanger
11. Water cleaning unit
12. Sludge tank
13. Monitoring equipment

The PureSOx scrubber

As the main and most visible component, the scrubber itself is the focal point of a PureSOx system.

Scrubber design

In most cases the PureSOx scrubber is configured with a split U-design. Suitable for the vast majority of vessels, this configuration offers a number of advantages. For example, the shape of the scrubber itself forms a natural water trap, preventing water backflow to the engine without any additional equipment.

For more about the advantages of a split scrubber design, refer to *Configuration criteria* on page 27.

Inlets for multiple exhaust gas sources

PureSOx scrubbers can be configured with multiple inlets. This allows one PureSOx scrubber to clean exhaust gas from both main and auxiliary engines, as well as boiler exhaust gas.

Multiple inlets greatly reduce the footprint and weight of the scrubber system overall, along with the cost of the equipment and installation.



PureSOx components and their function

The following descriptions provide a brief overview of the main PureSOx components and their function.

Jet section

PureSOx cleans the exhaust gas in two steps, the first of which occurs in the jet section. Here the exhaust gas is cooled by the water as it passes through, enabling the first reduction in SOx content.

Absorber

After passing through the jet section, the exhaust gas enters the absorber. This is where the second step in cleaning occurs. Here the SOx content is reduced to the necessary level, after which the cleaned exhaust gas leaves the funnel. The efficient water supply to the inside of the absorber reduces the demand for water at partial load, yet there is no risk of uncleaned exhaust gas being released into the environment.

Together with the jet section, the absorber has a noise-attenuating effect.

Uptake and bypass dampers

The uptake and bypass dampers (or valves) are used to lead the exhaust gas in the desired direction. When the scrubber is in operation, the exhaust gas is led from the engine or boiler through the respective uptake damper to the scrubber, while the respective bypass damper remains closed. As soon as the scrubber is idle, the bypass damper opens and the uptake damper closes, allowing the exhaust gas to exit the funnel.

In a multiple-inlet system, when scrubbing exhaust gas from one source but not another, the back-flow of exhaust gas must be avoided for the safety of the crew. To ensure this, Alfa Laval uses double-disc valves with sealing air, in which the slight overpressure between the discs enables a gas-tight seal. As an added benefit, the sealing air keeps the valve from sticking to its seat and prevents the build-up of soot.

Sealing air fans

Fans provide the sealing air necessary to close the double-disc valves of the uptake and bypass dampers. The use of air with the valves ensures there is no risk of the valves sticking to the funnel. In addition, the fans are used to pass clean air through the scrubber, rather than exhaust gas, when maintenance is necessary.



Bypass damper

Feed pumps

Feed pumps provide the flow of seawater to the scrubber in open-loop mode. Located deep within the vessel, below the water level, they must be powerful enough to overcome the difference in elevation between pump and scrubber.

In most cases two centrifugal pumps are used, with redundant pumps available as an option.



Feed pump

Circulation pumps

Circulation pumps provide the flow of recirculated water in closed-loop mode. These are usually much smaller than the feed pumps used in open-loop mode, because the flow is much smaller and there is less of a difference in elevation between pump and scrubber. In most cases two centrifugal pumps are used, with redundant pumps available as an option.

Circulation tanks

Circulation tanks of glass-reinforced epoxy (GRE) and polypropylene (PP) are an essential part of a closed-loop or hybrid configuration, as they allow long periods of closed-loop operation without water discharge.

The tanks provide a buffer for the system, eliminating the need to constantly add or bleed off water. Due to the low water flow in closed-loop mode, there is more time for the chemicals to react with the circulation water.

Consumables

Closed-loop operation requires desalinated circulation water, as well as dosing with an alkaline additive in the form of caustic soda. Each of these is stored in a dedicated tank or silo. The amount of circulation water needed varies with the ambient and seawater temperature. The amount of caustic soda is directly determined by the engine load and the sulphur content of the fuel.

Water cleaning unit

The water cleaning unit is a specialized example of an Alfa Laval core technology: the high-speed centrifugal separator. Developed over the course of several years, it removes the soot from the circulation water in closed-loop mode. The unit is completely unaffected by pitch and roll, which sets it apart from other cleaning systems on the market, and it can operate 24/7 in closed-loop mode. It has a footprint of just 6 m² and a modular construction based on three flexibly placed skids.

Sludge tank

During closed-loop operation, the soot removed by the water cleaning unit is collected as sludge. This sludge is stored in special sludge tanks, as it cannot be mixed with other sludge. The scrubber sludge is deposited on shore in the same way as other sludge produced aboard the vessel.

Plate heat exchanger

Cooling is provided by a high-efficiency plate heat exchanger (PHE). Alfa Laval has many decades of experience in PHE design and can provide an optimal balance between space, flow and investment. Designed with maintenance in mind, Alfa Laval PHEs have a five-point alignment system that makes them easy to assemble and disassemble.

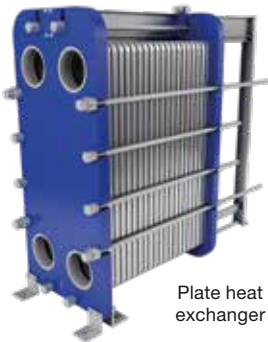


Plate heat exchanger

Monitoring equipment

Performance monitoring is necessary to demonstrate compliance with IMO regulations. Alfa Laval

monitoring equipment is selected for easy maintenance and maximum reliability under the most difficult real-life conditions.

Alfa Laval Remote Emission Monitor (ALREM)

Part of all new PureSOx deliveries and also available for retrofit, the ALREM is a data reporting and storage device that paves the way for a growing range of data-driven services. In addition to providing user-friendly compliance summaries via the Alfa Laval Touch Control system, it can log diagnostic and performance data as part of the PureSOx connectivity programme.

Alfa Laval Touch Control

PureSOx is fully automated and its control system is designed for easy integration with other vessel control systems. The Alfa Laval Touch Control system has a touchscreen display providing a graphical overview and access to any function or data in just two touches.



Monitoring equipment



PureSOx compatibility and integration

PureSOx is designed for compatibility with all engines. The system has been successfully installed with engines from all major engine builders, including MAN, Wärtsilä, MaK and Sulzer. In some cases, it has been sold in consortium with the engine manufacturer.

PureSOx is also designed for high flexibility in order to suit the broadest possible range of vessels.

In both its physical construction and its connection to general vessel control systems, PureSOx is well integrated with the vessel. Start-up takes less than one minute, as do transitions between operating modes in a hybrid system.

PureSOx and ease of use

PureSOx requires little from the crew. The system is fully automated, which means starting it up, as well as switching between open-loop and closed-loop modes in a hybrid system, can be done at the push of a button.

Even crews with no experience of scrubbers will be familiar with the majority of PureSOx components. Maintenance is limited, and the few points required can be performed while the engine is running. Sludge production in closed-loop operation is minimized by the efficient water

cleaning unit, and the sludge is disposed of on shore with the vessel's other sludge streams.

In the event of an emergency stoppage, the engine can be run independently. In most PureSOx systems, this is ensured by a "fail-safe open" function in the bypass valve.



PureSOx connectivity

To further support ease of use, as well as ongoing scrubber optimization, Alfa Laval has established a dedicated connectivity programme for PureSOx. The programme comprises a growing range of data-driven services, aimed at further simplifying compliance and providing new ways to save time and money. It builds on the Alfa Laval Remote Emission Monitor (ALREM), a data reporting and storage device.

On all vessels where the ALREM is installed, simplified compliance reporting is available. Rather than analysing scrubber compliance data themselves, operators can access user-friendly, graph-based reports via the Alfa Laval Touch Control system on board. These finished compliance summaries can be handed over to authorities directly.

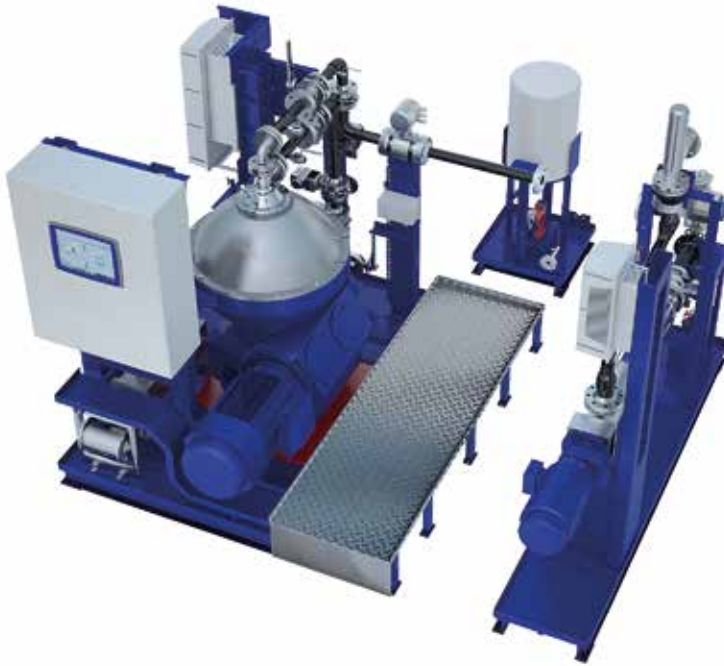
The compliance data for a vessel or fleet can also be accessed via an online portal, available on a monthly subscription basis.

The capabilities of the ALREM go far beyond reporting, however. The system can log not only the required compliance data, but also PureSOx diagnostic and performance data that can be sent to the cloud for processing by Alfa Laval analysts. This lays the groundwork for further services to come, including condition-based maintenance and operational fine-tuning based on best practices within a fleet.

The expertise behind PureSOx

The strengths of PureSOx as a system are tied to the strengths of Alfa Laval as a supplier. Alfa Laval is a world leader with a century of marine experience, including a half-century of experience with marine scrubbers specifically. Scrubbers are an integral component of inert gas production systems, which Alfa Laval has provided to oil, chemical and LNG carriers for over 50 years.

Other Alfa Laval core technologies are also a part of PureSOx. These include high-speed centrifugal separation, which Alfa Laval pioneered and continues to push forward. Used for water cleaning during closed-loop operation, centrifugal separation is currently the only alternative that performs reliably in rough waters. The PureSOx water cleaning unit is a unique application of this technology, developed over the course of several years.



Alfa Laval delivery and support capabilities

Alfa Laval's strengths as a scrubber supplier extend beyond technical capabilities to global resources and logistics. Through involvement with the largest SOx scrubber installations in the industry, Alfa Laval has established best practices that ensure on-time delivery and a smooth working process.

PureSOx is delivered as prefabricated components and modules, with every aspect of its installation well planned in advance.

To save time, some preparation can be done with the vessel in operation, and the final commissioning can also be handled on route. With a capable shipyard and smart planning, the total vessel downtime is possible to limit to 2–4 weeks.

Like other Alfa Laval solutions, PureSOx is also supported from start to finish. Alfa Laval's global service network is available worldwide and around the clock, providing local-language support, advice and an extensive service portfolio.



PureSOx project documentation and approval

The design and installation of a scrubber system, as well as the process of putting it into operation, is a major undertaking involving several parties and phases.

Alfa Laval has clear responsibilities as the scrubber equipment supplier, but also provides comprehensive documentation to facilitate customer preparations, the work of the engineering company and installation by the shipyard.

Sale and design

During the sales process, Alfa Laval prepares a Technical Specification for the customer that forms the basis for the final contract. The Technical Specification contains initial drawings, aimed mainly at deciding the general placement of equipment. Once the contract is finalized, Alfa Laval initiates an engineering project led by a dedicated project manager to finalize the project-specific drawings of all components in Alfa Laval's scope. The remaining components (including pipework and cabling), as well as the overall installation, are designed by the customer's engineering company. To support this process, Alfa Laval provides a detailed Design Guide and a comprehensive Installation Manual.

Installation

When the customer has decided upon and made arrangements with a shipyard, Alfa Laval provides a Pre-Commissioning Checklist for the installation work. This document details all the procedures necessary in finalizing the installation and preparing it for commissioning by Alfa Laval.

Commissioning

Commissioning of PureSOx is performed by Alfa Laval. Through this process, Alfa Laval takes full responsibility for ensuring that the scrubber meets the requirements of MARPOL Annex VI. Included in the process is a Site Acceptance Test as agreed between Alfa Laval and the customer, which verifies that Alfa Laval's work has been carried out and that the customer can begin using the PureSOx system. When the system is operation-ready, Alfa Laval supplies a Basic Operations Manual detailing the full operation of PureSOx via the Alfa Laval Touch Control system. In addition, a Maintenance Manual is supplied with step-by-step instructions for maintaining the system.

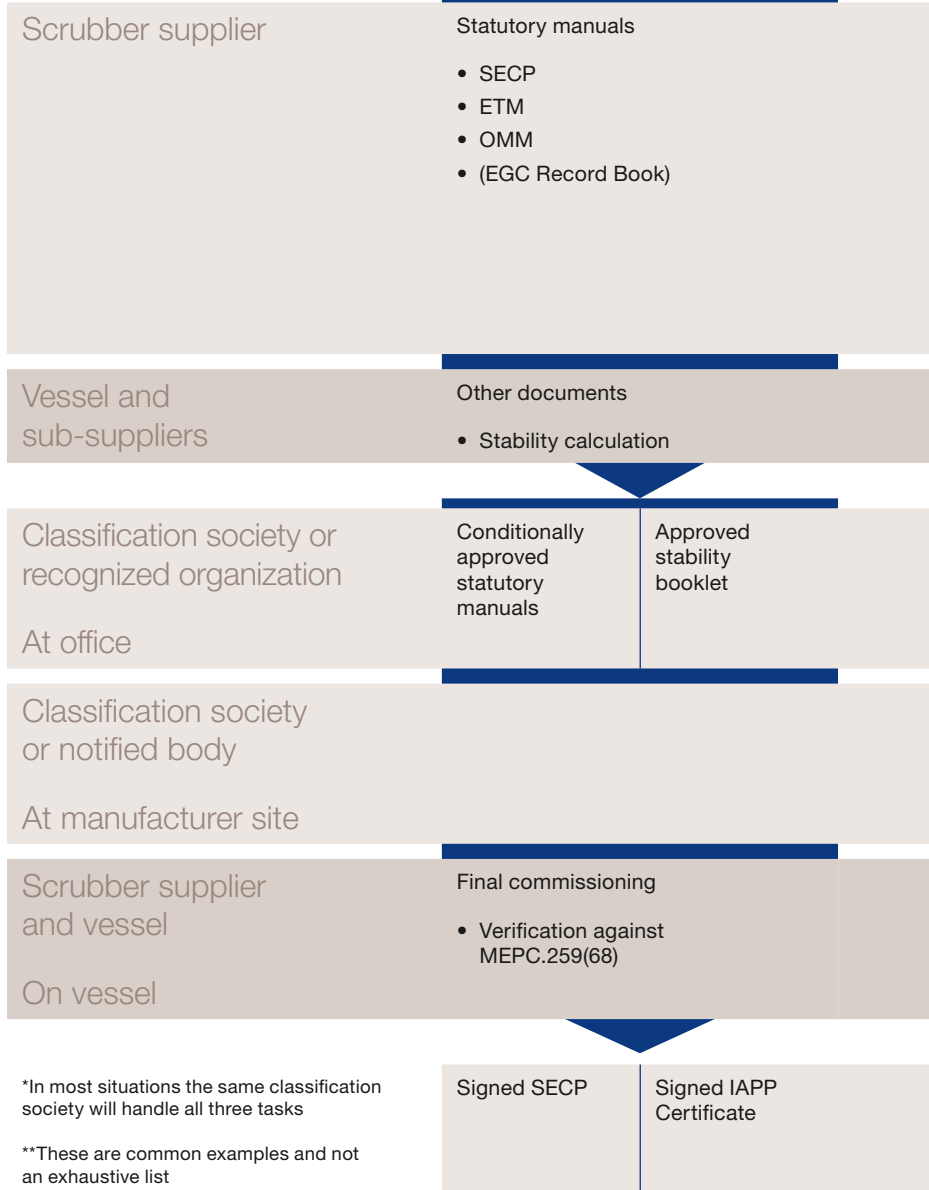
Class and Flag State Approval

The final step of achieving Class and Flag State Approval is a complex one involving many parties. Alfa Laval has developed clear procedures and documentation designed to simplify this process. A brief overview can be seen on page 62.

Approval Process – Scheme B

IMO regulation and local legislation

Recognized organization* on behalf of flag administration



Classification society rules

Classification society*

Documents for plan approval

- P&IDs
- Part lists
- Specified drawings
- Certified analysis equipment
- MSDS
- Electrical drawings
- Alarm and safety table
- Back pressure calculation/measurement

Documents for plan approval

- Piping details (GRE), etc.

Plan approval,
EGC

Plan approval,
ship

MED certification (EU)

Notified body*on behalf of
flag administration

MED certification documents**

- Declaration of conformity
- WPS, WPQR, WQRT
- Material certificates
- Production drawings

Quality control

Final acceptance test

- Control system
- Hydro tests
- Back pressure

Quality control

- Verification against
MEPC.259(68)

Class Approval, EGC

MED Certificate

PureSOx references

The PureSOx system today builds directly on the original PureSOx technology, which has been continuously developed and optimized. This means that PureSOx has more references than any other single SOx scrubber technology.

Every PureSOx system ever supplied is still in use and operating in compliance with MARPOL Annex VI limits.

The PureSOx reference list comprises a broad range of vessel types, some of the world's largest SOx scrubbers and installations that handle exhaust gas from multiple sources, including boilers. Most importantly, it includes many repeat orders from satisfied customers.





Returning customers

PureSOx has more references than any other single SOx scrubber technology, many of which are repeat orders. All PureSOx systems ever installed are still in compliant operation today.

Finnlines and ACL RoRos and ConRos for Grimaldi Group:

- Five open-loop PureSOx systems with multiple inlets
- Five hybrid PureSOx systems with single inlets

"We are very satisfied in our dealings with Alfa Laval, in terms of both project execution and the technical performance of the PureSOx scrubber. The systems already delivered have all received class approval, and we expect equivalent results from the deliveries in progress."

Emanuele Grimaldi, Managing Director, Grimaldi Group



System flexibility

PureSOx offers a high degree of system flexibility, with multiple operating arrangements and other options as well. These possibilities allow almost any challenge to be overcome, even on vessels with space and stability issues.

Buss Shipping container vessels:

- Two hybrid PureSOx systems with multiple inlets

“The PureSOx solution was well engineered and allowed a sophisticated integration of the scrubber system into our container feeder ships. The custom construction let us avoid major modifications inside the vessel, which together with the pre-outfitting gave us a short installation time. All those factors contributed to a competitive price.”

Christoph Meier, Project Manager, Buss Shipping



Core technology

Alfa Laval has over 50 years of experience with scrubbers, as well as over a century of experience with centrifugal separation. Centrifugal separation is the most reliable method of water cleaning, which is vital for the compliance of a closed-loop or hybrid scrubber system.

RCL cruise ships:

- Three hybrid PureSOx systems with multiple inlets
- One hybrid PureSOx system with a single inlet

"[Our vessels'] area of operations will require a closed-loop mode with reliable water cleaning. This is where Alfa Laval's separation expertise comes into play."

Kevin Douglas, Vice President, Technical Projects and Newbuild, RCL



Project management

Alfa Laval's track record and structured method of preparing scrubber installations offer insurance against expensive delays. Alfa Laval has many years of experience and a strong delivery infrastructure, plus well-documented procedures and clear project management that facilitate class approvals.

EXMAR LPG carriers built by Hanjin Heavy Industries & Construction (HHIC-PHIL INC.):

- Two hybrid PureSOx systems with multiple inlets

"Alfa Laval has made things easier in our work with EXMAR so far, and we anticipate that will continue as the EXMAR projects progress. We expect a lot from Alfa Laval as an experienced marine supplier, and when it comes to the professional level of support regarding PureSOx and exhaust gas cleaning, the company delivers."

Lee Dong-hoon, Senior Manager, Hanjin Heavy Industries & Construction (HHIC-TMS)



Global service

A scrubber will be with its vessel for many years, and will affect the vessel's resale value. A stable supplier with a strong global network – who can offer assistance wherever the vessel sails – is important. Alfa Laval has served the marine industry for a century, providing service and support both world-wide and 24/7.

DFDS RoRo and RoPax vessels:

- Four hybrid PureSOx systems with multiple inlets
- Nine hybrid PureSOx systems with single inlets

“We’ve been extremely pleased with the cooperation with Alfa Laval. DFDS’s policy is that we will never ever bring us in a situation where we can’t comply with the legislation.”

Kasper Moos, Vice President Technical Org., DFDS Seaways

Ongoing development of PureSOx

Working with SOx emissions is part of Alfa Laval's overall effort to reduce customers' environmental impact and to help them comply with new legislation. Alfa Laval has an active programme of development for PureSOx, along with other environmental solutions.

Much of the ongoing PureSOx development occurs at the Alfa Laval Test & Training Centre, a unique research facility located in Aalborg, Denmark. With its 1350 m²

testing space, the centre is a full-size machine room on land, with complete process lines integrated around a 2 MW marine diesel engine. The 1.5 MW PureSOx scrubber installed here can be pushed to its limits under controlled conditions, which accelerates both the speed and quality of testing.

Additional PureSOx development takes place at Alfa Laval's product centre in Nijmegen, the Netherlands.

Alfa Laval Test & Training Centre





Opportunities for dialogue

There are naturally many questions about SOx abatement technology among potential scrubber customers. Alfa Laval has an open approach to discussing both challenges and solutions.

As a part of investigating a purchase, a visit to an actual PureSOx installation can be arranged. This will facilitate more concrete discussions of the technology and its possibilities. Inquiries can be made by email: PureSOx@alfalaval.com

Scrubber supplier selection guide

There are key issues to consider when evaluating potential equipment suppliers and their SOx scrubber systems. The questions and explanations in this selection guide highlight some of the most important. A checklist follows for use in your own supplier discussions.

1. Does the supplier possess core technology in all necessary areas?

While scrubbers are proven to work and simple in principle, it takes considerable knowledge to optimize their function – especially in the marine environment. Your supplier should be experienced in the supply of marine solutions and should ideally have a specific history with scrubbers. If you intend to purchase a closed-loop system, you should also look for a supplier with a deep

knowledge of separation, as this will be necessary to ensure compliant cleaning of the scrubber circulation water. In-house knowledge of auxiliary equipment such as plate heat exchangers is a bonus.

2. Has the supplier worked continuously with one SOx scrubber technology?

The development of SOx scrubbers has been intense in recent years. Many players have entered and left the market, and many technologies have switched hands. Even some of the largest suppliers have changed their technologies along the way, or purchased technologies that were not developed in-house. The longer a supplier has owned and optimized its technology, the stronger that technology is likely to be.



3. Can the supplier ensure performance for specific sailing profiles regardless of operating conditions?

The marine environment is an unpredictable one. Rough seas, as well as rapidly changing engine loads, place extreme demands on equipment performance. Your SOx scrubber should be reliable in all conditions, even when it comes to water cleaning during closed-loop operation on stormy seas. The supplier should also be able to ensure compliance in the specific areas where your vessel sails, especially if your sailing profile includes both global and ECA operation.

4. Can the supplier ensure simple and smooth operating transitions?

Your SOx scrubber should not add complexity to the operations on board. Nor should it affect engine operation if it has to stop in an emergency. If you choose a hybrid scrubber, you should also expect a fast, simple switch between operating modes.

5. Does the supplier have significant experience with exhaust from two- and four-stroke main engines?

Some of the SOx scrubbers today have seen little real-life operation or have mainly been used in smaller installations with auxiliary engines. No matter what size or type of engines your planned installation involves, a system that has been proven to work with the greater safety requirements, higher power and higher variable load of main engines is a more robust choice.

6. Has the supplier received repeat scrubber orders from customers?

Nothing says more about a SOx scrubber or its supplier than the trust placed in them by customers. An extensive reference list is valuable, but the most important references are those where the same customer has purchased a system multiple times. The decision to purchase again, based on successful operation at sea, is the best seal of approval available.



7. Are all SOx scrubbers provided by the supplier (including trial systems) still operating well?

A supplier's reference list should be examined critically. Many suppliers have tried and abandoned technologies, or found them difficult to optimize. If all of a supplier's SOx scrubber installations – including trial installations – are still operating to the customer's satisfaction and in compliance with MARPOL Annex VI limits, it is an indication of a sound technological platform and ongoing optimization.

8. Does the supplier have a track record of meeting delivery times?

A spotless delivery track record is vital. If a supplier is unable to get equipment to your shipyard during the scheduled time slot, you incur a great deal of additional expense. As various environmental regulations demand new equipment on board in coming years, supplier resources and shipyard slots will likely be increasingly hard to come by.

9. Can the supplier minimize time out of service for installation and commissioning?

While the installation of a SOx scrubber is a major undertaking, your supplier should be able to minimize the time during which your vessel is out of service. With smart supply solutions, good planning and commissioning en route, it should be possible to limit your downtime at a capable shipyard to 2–4 weeks.

10. Does the supplier have global service and support capabilities?

Your SOx scrubber is a solution that will be with your vessel for many years. This makes it important to choose a stable supplier with a strong global network, who can provide long-term service and support wherever your vessel sails. In the unlikely event of a system failure, you want 24/7 access to your supplier's services, no matter where you are.

Scrubber supplier checklist

The following checklist can facilitate your discussions with potential equipment suppliers. For explanations of the issues behind the questions, refer to the *Scrubber supplier selection guide* on pages 72–75.

-
1. Does the supplier possess core technology in all necessary areas?

 2. Has the supplier worked continuously with one SOx scrubber technology?

 3. Can the supplier ensure performance for specific sailing profiles regardless of operating conditions?

 4. Can the supplier ensure simple and smooth operating transitions?

 5. Does the supplier have significant experience with exhaust from two- and four-stroke main engines?

 6. Has the supplier received repeat scrubber orders from customers?

 7. Are all SOx scrubbers provided by the supplier (including trial systems) still operating well?

 8. Does the supplier have a track record of meeting delivery times?

 9. Can the supplier minimize time out of service for installation and commissioning?

 10. Does the supplier have global service and support capabilities?

Alfa Laval

	✓			
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For further information

The following documents provide valuable guidance in evaluating scrubber technologies and their impact.

- *Understanding exhaust gas treatment systems: Guidance for shipowners and operators (June 2012)*, Lloyd's Register
- *Assessment of possible impacts of scrubber water discharges on the marine environment*, Danish Ministry of the Environment
- *Vessel emission study: Comparison of various abatement technologies to meet emission levels for ECA's*, Green Ship of the Future*
- *Exhaust Gas Scrubber Installed Onboard MV Ficaria Seaways*, Danish Ministry of the Environment*

*These documents contain specific studies involving Alfa Laval PureSOx. Additional information about PureSOx, including multimedia content, can be found at www.alfalaval.com/puresox





Contact Alfa Laval

Specific inquiries about PureSOx can be directed to:

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E-mail: PureSOx@alfalaval.com
Telephone: +31 24 352 31 00

You may also use the online form on the *Contact* page at www.alfalaval.com/puresox

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

Up-to-date Alfa Laval contact details for all countries are always available on our website at www.alfalaval.com