EXHAUST GAS CLEANING
HOW TO CHOOSE THE CORRECT SCRUBBER

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WÄRTSILÄ MOSS BUSINESS WHITE PAPER
HOW TO CHOOSE THE CORRECT SCRUBBER

WÄRTSILÄ

How to choose the correct scrubber

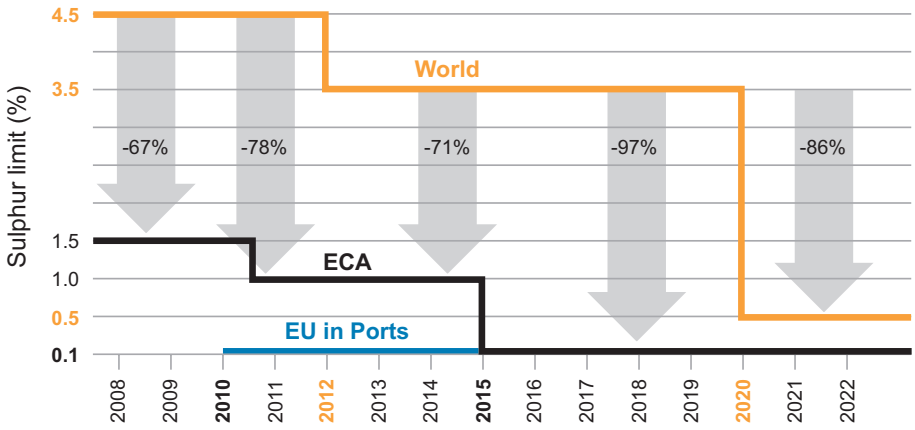
Introduction

Most ship owners today should have heard about scrubbers by now. To some it will be a highly familiar subject, having gone through the process of evaluating a scrubber option, or having even installed a scrubber system, for their fleet, whilst for others it is still a big question mark. Getting to know the rules about the upcoming sulphur limits, and the alternatives for complying, can be a hassle in itself, rendering the process of understanding the whole concept of exhaust gas cleaning a bit overwhelming. Which scrubber should one choose? Which one is best? What is the difference between open loop and hybrid, and will they be legal in the future?

Legislation

There is much discussion, both from regulatory bodies and various experts, all with different opinions, along with a lot of rumours to twist our necks, leaving us not knowing whom to listen to. Suppliers are not making it easier by constantly upgrading their equipment, and often changing the names of the available products. On top of everything, there is the added pressure that the decision must be made soon. The regulations regarding Emission Control Areas (ECAs) will be tightened already in January 2015, which means that those operating in these waters should already have a plan. After this there is the world limit looming ahead, which will be enforced in 2020. Let's now have a look at some of the issues when installing an exhaust gas cleaning system, so as to hopefully give an idea of how to choose the right scrubber.

Figure 1:
Current and upcoming sulphur limits from the IMO. The stricter world limit is post poned until 2020.



Fuel type	Not regulated - both HFO and distillate are permitted.
Exhaust gas cleaning	Permitted alternative under Regulation 4 to achieve regulated limit.
Particulate Matter (PM)	No limit values.

Scrubbing technology and the environment

Let's start from the beginning, as experience tells us that exhaust gas cleaning can be a tricky subject if one doesn't have all the facts on the table. It's also important to give some of the spotlight to the environmental impact of scrubbing, as it often gets sidestepped by all the talk of rules, cost and payback time.

Sulphur oxides are formed in a combustion process, when the sulphur in the fuel oxidizes, thus forming sulphur oxides (SOx). Sulphur oxides dissolve in water. This means that when emitted into the atmosphere they will dissolve in the water in the air and form acid rain. Acid rain is very harmful to people and the environment, as it will destroy land, crops, fresh water lakes and buildings. However, the fact that SOx dissolve in water also makes possible the technology

for scrubbing. In a scrubber, the exhaust gas is sprayed with alkaline water. The sulphur oxides will dissolve in the water and be removed from the exhaust gas, along with some other harmful emissions, such as particulate matter. If the wash water from the scrubber is cleaned before being discharged into the sea, a lot of particulates and heavy metals that have been cleaned from the exhaust gas will also be removed. Under normal circumstances without a scrubber installed, these emissions will be exhausted into the atmosphere. A lifecycle analysis to evaluate the use of scrubbers compared to running on low sulphur fuel was recently carried out by Shell . The study concluded that running on HFO with a scrubber installed will actually be more beneficial for the environment than running on MGO, as the refining processes are comprehensive. This is naturally just one study, but it nevertheless indicates that we are heading in the right direction.

Complying with the rules

Once one has an idea of what a scrubber is and what it is used for, the evaluation of whether a scrubber is the best option for the particular vessel can begin. There are mainly two alternatives for complying with the new sulphur legislation; low sulphur fuel and exhaust gas cleaning. If the ship is already running on a low sulphur fuel, and is compliant with the rules, there is obviously no need to install a secondary cleaning method. One might also want to have a look at the annual fuel usage, and compare it to the installation cost and OPEX of a scrubber system. This might be highly relevant for an existing vessel, where the remaining lifetime is limited and the installation cost is higher than for a new build. The big advantage of a scrubber is that it will enable the ship operator to run on cheaper high sulphur fuel, and still be compliant with the sulphur limits. This means that the scrubber will pay for itself in the form of fuel cost savings. The return on investment (ROI) will depend on the price difference between HFO and MGO.

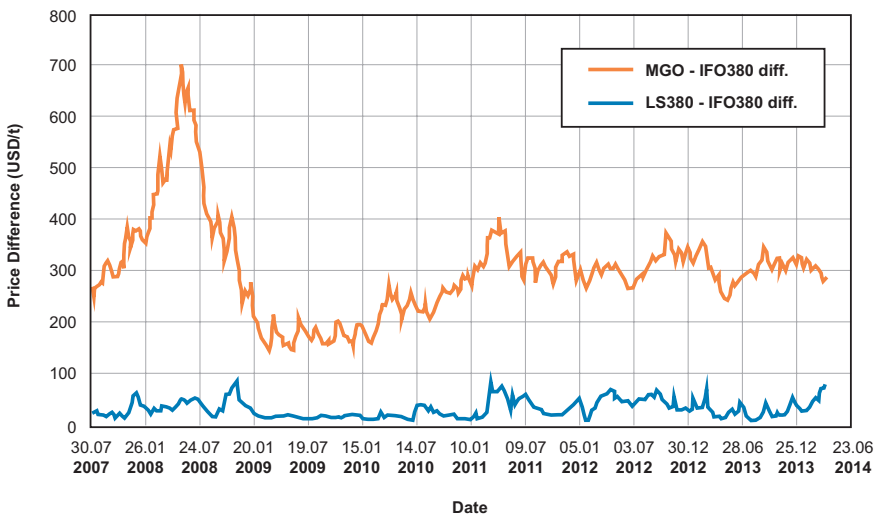


Figure 2:
Fuel prices, Rotterdam. The price for low sulphur fuel is expected to rise.
Source: Bunkerworld

There are of course other low sulphur fuels available on the market or that are being developed, which might be interesting for certain vessels. Liquefied Natural Gas (LNG) is at the forefront of these with the technology and procedures already available, even though the supply infrastructure is still not fully developed. Running on LNG will solve several emission problems, as it will fulfil both the strictest SOx legislation and also comply with the Tier III NOx (nitrogen oxides) rules from the IMO. Running on LNG will also reduce particulate matter. This would be a good alternative for ships, such as ferries for example, that operate on set routes. For most vessels though, the installation of a scrubber is a solid business case.

Open loop, closed loop and hybrid

As the scrubbing technology is such an attractive solution, there are quite a few suppliers on the market today. This is naturally beneficial in that it leads to healthy competition and constant development of the technology. The not so great thing about having many suppliers is that the terminology has been used quite freely with the result that one supplier's hybrid scrubber can be very different from the next. This confusion, together with the different product names the different suppliers have come up with, can leave one's head buzzing.

This article will focus on wet scrubbers, as they have been thoroughly tested and validated. These represent the preferred cleaning method of today, which makes it the most relevant technology. A full wet scrubber portfolio includes open loop, closed loop, and hybrid scrubber versions. The terms "open loop" and "closed loop" usually mean pretty much the same, independent of the supplier, while the word "hybrid" is being used to describe a few different products out there. This has a simple reason; there is no such thing as a hybrid, at least not in the sense of functionality.

An open loop scrubber system means that seawater is utilized as scrubbing water. It is called an open loop because the water is taken from the sea, led through the scrubber, and then released back into the sea, thus forming an open loop. A closed loop system, however, will be filled with water which is then recirculated. The water is not, therefore, supplied from the sea and it is a closed loop. In a closed loop system only a small amount of the scrubbing water is let out from the system and released into the sea. There is often a misunderstanding that a closed loop will not have any discharge to the sea. This is never the case, as the scrubbing water cannot recirculate forever, but has to be gradually exchanged with clean water to maintain the cleaning efficiency of the scrubber. The discharge water can, however, be stored for a period of time in a tank to enable a zero-discharge mode. There has also been much discussion as to whether open loop systems will be allowed, due to the amount of discharged water. In my opinion, the discussion should not be about the open loop as a principle, but rather about what quality the discharged water should have. At Wärtsilä we have always been very strict on cleaning the discharge water, even from our open loop system, and are committed to following both current and future legislation. This is not always a popular choice to make, but we feel it is the right thing to do.

Now that the open and closed loop systems are all figured out, let us look at the hybrid option. A hybrid is, as the name suggests, some kind of mix between both systems. At Wärtsilä the name is used to identify a system that can run in both open loop and closed loop, enabling flexibility for customers operating in both low and high alkalinity areas. The term "hybrid" is also being used for other products, such as an open loop system where caustic soda (NaOH) is being added to the water to give the alkalinity already in the seawater an extra boost. The only thing one can really do to keep track is to ask the supplier to clarify what they mean by hybrid, and what the benefit is of having such a system.

Scrubber types and alkalinity

So which one of these should one go for exactly? In general, one system isn't better than the other. As long as one goes for a serious supplier with certified products, it is really a matter of looking at which system is best for the particular vessel. In the end it all comes down to alkalinity and the operating route. Alkalinity is the term used for the ability of water to buffer acid, and can to some extent be found naturally in all waters. In scrubbing, alkalinity is used to buffer

the SOx dissolved in the scrubbing water. The alkalinity will help in neutralizing the SOx and keeping the pH higher. On the open sea the alkalinity levels are generally high, and therefore the seawater can be utilized for scrubbing. This is what the open loop scrubber system does. There are, however, some areas in the world where the alkalinity is too low for open loop scrubbing to be practical. These areas include, for example, the American Great Lakes, the port of St Petersburg, and the Mississippi river. If a ship is operating full time in these areas, a closed loop system would be the best option as it uses caustic soda to buffer the scrubbing water's alkalinity. Thus, the system is independent of the alkalinity in the surrounding seawater. A hybrid can then be used for those vessels that mostly operate in high alkalinity waters, but enter low alkalinity areas for shorter periods of time. A hybrid will then enable the system to switch between open and closed loop, according to operational needs.

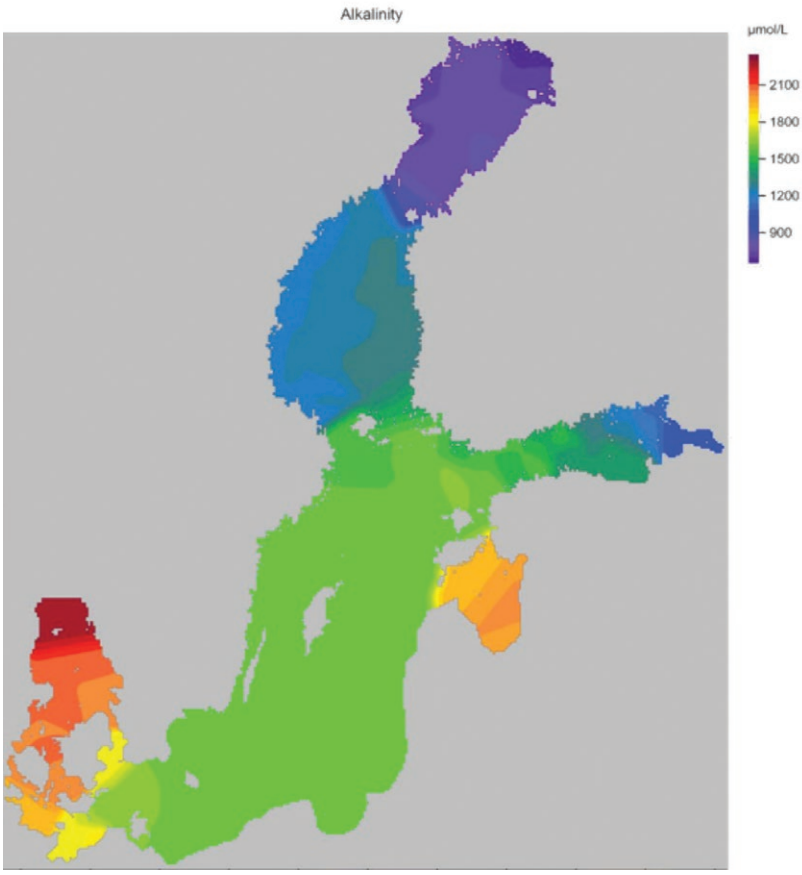


Figure 3:
Example of alkalinity variations in the Baltic Sea. A safety margin of 1000 µmol/L has been set for open loop scrubbing.

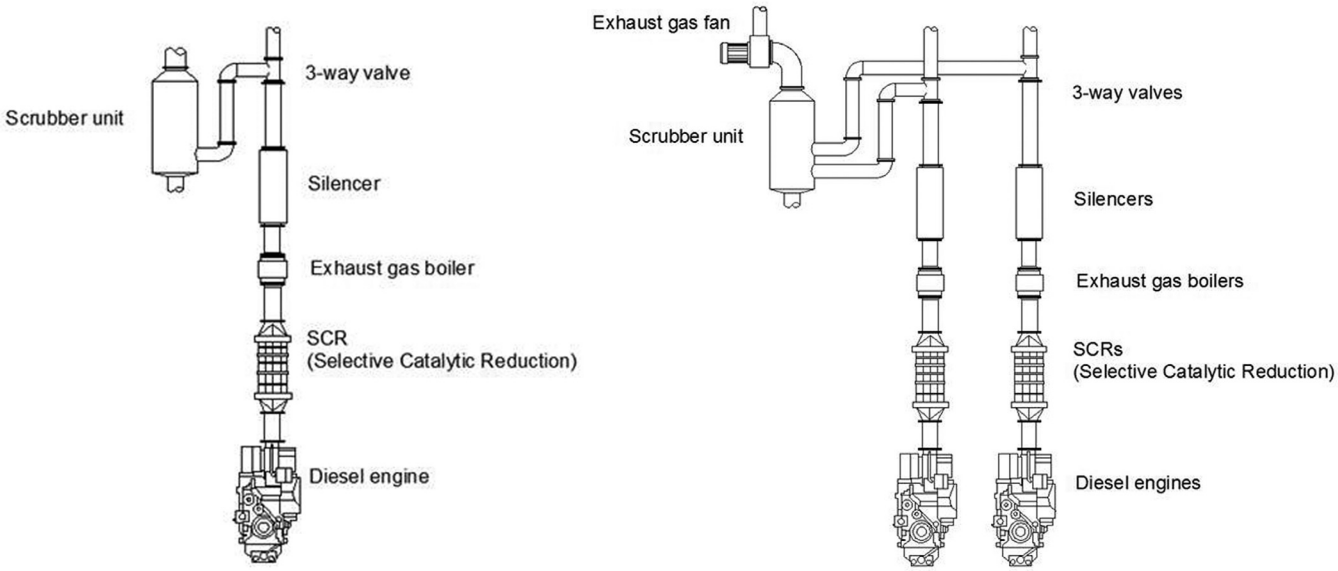
The different systems have benefits and drawbacks when considering CAPEX, OPEX and sometimes practicality. There might be other reasons for choosing a specific scrubber, other than just the alkalinity of the seawater on the vessel's route. If, for example, a ship operates in high alkalinity areas, but also in very shallow and sandy waters, one might want to consider installing a closed loop or hybrid system. This is because in an open loop, the sand will enter the system and cause wear to the equipment, especially to the water treatment units. This will add a lot of cost to maintenance. Another thing to consider is the amount of water running through the system, as one of the biggest costs when operating a scrubber is the power used for the pumps. The amount of water needed will be higher in an open loop than in a closed loop, and therefore the power consumption will also be higher. In a closed loop system, however, caustic soda is used and this will add some cost. The amount of equipment in the system will also naturally affect the investment cost. Open loop comes out looking best here, as it is the least complex system.

The perfect match

Once one has decided which scrubber system will fit the designated vessel best, it is time to have a look at the engine installations on board. There are generally two ways to go; one can have separate scrubbers for all engines and boilers, or one can have a combined unit for several engines or boilers. Because of the numerous technical and safety concerns, Wärtsilä has made the decision not to combine both engines and boilers into the same scrubber unit. This decision is also supported by boiler makers.

There are benefits and drawbacks with both combined and separate scrubber units. Separate units for each engine or boiler will allow considerable operational flexibility and will, therefore, most probably have a lower OPEX. The investment cost will, however, be higher than for a combined solution, as more equipment naturally means more cost. The combined solution will enable two or more engines or boilers to utilize the same scrubber unit, thereby saving space and investment cost. As mentioned though, these scrubbers will be less flexible, and will run for much of the time on “overload” if some of the attached engines are not running. It is always wise to discuss the best solution with a technical expert.

Figure 4:
Separate versus combined scrubber units.



To put this knowledge into practice and to further illustrate what has been discussed in this article, let us look at one of Wärtsilä's reference installations. Wärtsilä sold eight scrubber systems to Algoma, the first delivery being in 2012. In this case the closed loop system was chosen as the vessels will operate entirely inside the Great Lakes, where the alkalinity levels are low. A combined scrubber unit of 11 MW was installed for both the main and auxiliary engines to reduce both the investment cost and the space requirement. The potential loss of flexibility in the system was deemed manageable.

Summary

So to summarize, first look at the rules that are applicable where the vessel will operate. One should bear in mind that it's always the strictest legislation that needs to be followed. Furthermore, it is not only the IMO rules that need to be heeded, but also the local legislation in areas where the ship will operate. Secondly, have a careful look at the different options. Will the installation of a scrubber fit the vessel or should one go for another alternative? Many ship owners choose to get support from consultants at this point.

Once it has been concluded that a scrubber will be a good option for the vessel in mind, have another look at its operating route. Will the vessel enter low alkalinity areas and for how long? One might also want to keep in mind that until the world limit is enforced, the cost benefits of a scrubber will only be relevant in the emission control areas (or in the case of similar local legislation).

Finally, one needs to have a look at the machinery to be hooked up to the scrubber system. By looking at the operating profile and layout of the engine room(s), one needs to assess which kind of scrubber installation will fit best. This will, however, be quite challenging and most operators would now seek guidance from one or several suppliers. The suppliers will mostly be happy to offer relevant support along with their products, such as layout drawings, on board visits, payback time calculations, and power consumption estimations. Overall, it is recommended to involve technical experts from the supplier already in the early planning stage of installing a scrubber, as the process is often quite lengthy. This is not an "off-the-shelf" product and cannot be treated as such. Every vessel is unique, which means that so too is each scrubber system.

Want to know more?

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