



White paper



Marine exhaust gas cleaning:

# Optimizing maintenance for SO<sub>x</sub> scrubbers

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## Overview

When a SOx scrubber is the strategy for meeting marine emission limits – whether those of the 2020 global sulphur cap or the stricter limits in Emission Control Areas (ECAs) – it becomes key to the vessel's compliance and economy. Although the technology, design and quality of the scrubber are vital to its success, the way it is operated and maintained will have a decisive impact on its performance during its lifetime.

With this in mind, it is crucial to adopt the right scrubber maintenance strategy and to choose the right service provider to implement and safeguard it. This will result in the most reliable operation and optimized performance, which in turn will secure compliance, keep costs to a minimum and make them predictable. The issues and considerations involved are presented briefly in this paper.

# What is an optimal maintenance strategy?

Naturally, there is no one-size-fits all solution for SOx scrubber maintenance. Between the choices of performing all maintenance in-house and outsourcing the majority of it to a service provider, there are a range of intermediate possibilities. Which solution is optimal for a given vessel or fleet will depend on a variety of considerations, including:

- The maintenance prescribed by the scrubber supplier
- The crew's competence level
- The vessel's operational profile and sailing routes
- Available budget
- Willingness to take on risk

All of the above will influence the type and frequency of maintenance needed, as well as the importance of supplier-related factors such as spare parts availability and access to remote support. However, one of these points is often overlooked, although important: the willingness to take on risk.





## Maintenance as risk mitigation

A SOx scrubber is a compliance solution, which means that meeting the demands of legislation is the driving factor for its installation and use. If the vessel should fall out of compliance, there is a risk of significant fines or vessel detention – which may prove even more costly. Performing timely and correct maintenance to keep the scrubber in optimal condition is a way of mitigating this legal risk.

Likewise, proper maintenance mitigates the risk of operating losses. These can occur through poor scrubber performance that increases OPEX, or through downtime that prevents the use of the scrubber at all. The latter would necessitate continuing the voyage to the next port under the advisory of the flag state, rerouting or making a temporary switch to more expensive low-sulphur fuel.

The significance of each of these risks is a matter for individual judgment. The risk calculation for a ferry on a one-day return route may be different from that of a bulker on a global route of several weeks. Certainly, the latter vessel faces a potentially longer wait for field service support or spares to arrive. In its case, precautions such as onboard spare kits and access to remote support may be of increased value.

In short, when determining a maintenance strategy, fleet stakeholders must weigh the importance of peace of mind. In other words, how valuable is it to ensure that the scrubber will perform as it should?

# Types of maintenance

There are different ways of handling maintenance, which may be called by a broad range of names. Roughly, however, maintenance can be divided into three types:

## 1. Corrective maintenance (CM)

Corrective maintenance, also referred to as run-to failure, is reactive in nature and is used to repair or replace parts only when they actually fail. It is usually applied to less critical assets, as it assumes that failure is acceptable and not possible or economical to prevent.

Corrective maintenance is a common approach, whether by active choice or as a result of not making one. It requires minimal thought, planning and staff, and therefore costs little as a strategy. However, since failure is unpredictable, its costs in practice can be very high, especially if the vessel falls out of compliance as a result.

## 2. Preventive maintenance (PM)

This is also referred to as planned or time-based maintenance and focuses on replacing parts upon a fixed time, interval or usage, regardless of their condition. Equipment is inspected even though it has not presented any symptoms or caused any problems.

With a preventive maintenance programme in place, the risk of unexpected downtime is decreased. However, since parts are replaced based on a schedule and not their actual condition, some cost is incurred through the replacement of parts before the end of their useful lifetime.



### 3. Predictive maintenance (PdM)

Predictive maintenance aims to foresee when a failure might occur and take proactive steps to prevent it from happening. Since it is based on the actual condition of the equipment, rather than on specified intervals or equipment age, it is sometimes referred to as condition-based or just-in-time maintenance.

Predictive maintenance requires an advanced technical solution to monitor equipment status and performance in real time, built on mathematical algorithms that identify trends and accurately predict failure. While the strategy itself is more complex, the fact that failure is avoided without premature exchange of parts minimizes the total cost.

The relationship between maintenance costs and the frequency of equipment failure is different for each of the maintenance types described. Most SOx scrubber owners carry out a mix of preventive and corrective maintenance. However, it is predictive maintenance that offers the ideal balance, as illustrated in Figure 1.

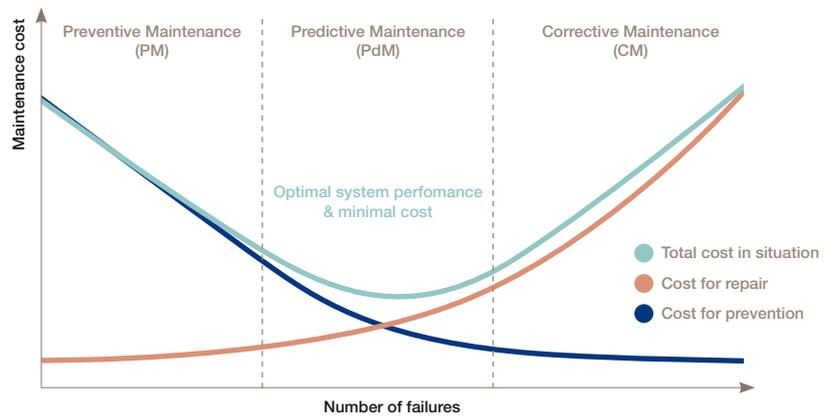


Figure 1: Maintenance types and their cost balance

As the figure shows, predictive maintenance optimizes the trade-off between maintenance costs and operating costs. It offers high equipment availability and reliability, yet it avoids both unnecessary maintenance activities and costly reactive corrections. While data-driven digital services are required to achieve it, these are now available for marine SOx scrubbers, as described later in this paper.

# Choosing a service provider

Outsourcing maintenance can make it easier to achieve an optimal maintenance strategy. The technical knowledge offered by a service provider can supplement that of vessel crews, just as the availability of spare parts can limit stocking costs for both vessel and fleet.

Some good questions to ask when considering a service provider are:

- Does the provider have a service strategy?
- What is the scope of the provider's service offering?
- Does the provider offer tailored service solutions?
- What is the provider's track record of service?
- Does the provider have a global service network in place?
- How is the provider's service and spare parts availability?
- Is there a clear speaking partner at the provider?

The right service provider can act as a partner, delivering more than the standard supply of parts and ad hoc corrective maintenance. Ideally through predictive maintenance and performance guarantees, the provider can secure peace of mind and allow fleets to focus on their core business.





## Field services

Qualified field service expertise is an important aspect of a potential service provider's offering. The accessibility of field services should always be considered, since global access will help ensure operational flexibility and more predictable costs. Though the services offered will vary between providers, three common ones are:

- System inspection
- Sensor calibration service
- Training

### System inspection

Performing regular system inspections will preserve a SOx scrubber's reliability and longevity. An annual onboard equipment survey, for example, can help prevent failure and unplanned downtime, thus avoiding unexpected repair costs.

A system inspection provides:

- A clear overview of any cleaning, maintenance and repair needs
- Recommendations for optimizing maintenance to avoid unexpected costs
- Insight into crew performance and room to discuss operational questions
- Certainty of complying with SOx legislation
- Identification of any potential gaps in spare parts inventory

Typically, a detailed inspection report is provided after the onboard survey. This report details actions undertaken during the visit and contains recommendations for addressing any issues found. Overall, it provides a clear picture of the scrubber's condition at the time of the visit.

### Sensor calibration service

A sensor calibration service simplifies the maintenance of the sensors that prove a SOx scrubber's compliance. To retain their accuracy, these sensors must be periodically removed for factory servicing, which involves cleaning, inspection, replacement of wear parts and recalibration. Via the sensor calibration service, the service provider supplies newly calibrated replacement sensors before such servicing is due.



Since the sensors cannot be serviced on board, this avoids a situation where the vessel either cannot prove its compliance for a certain time or must maintain an expensive sensor stock. The coordination, stocking and logistics are all handled by the provider, while the scrubber remains in compliant operation.

Other advantages of a sensor calibration service typically include warranty on the sensors while participating in the programme, as well as the provision of an audit-worthy statement and certificate from the provider, declaring the timely replacement with newly calibrated sensors.

## Training

Training supports efficiency and compliance by ensuring that vessel crews have the skills to perform routine maintenance and operate the SOx scrubber safely and correctly, as well as to perform basic troubleshooting. Having a well-trained crew helps prevent unexpected problems and reduces both maintenance and operating costs.

Training can take many forms, from classroom or practical hands-on instruction to e-learning. Likewise, it can extend from basic equipment and maintenance familiarization to more advanced solution training. Service providers may offer standardized courses or customized instruction, tailored to suit particular needs.

In general, training is an opportunity to align crew knowledge and bring new employees on board. It helps crews to:

- Understand the scrubber's function
- Work with the equipment safely
- Ensure successful operation and reliable performance
- Troubleshoot minor issues
- Optimize maintenance



## Digital services

Concepts like big data, machine learning and the Internet of Things (IoT) are considered the future in many industries – the marine industry included. Digital services promise an entirely new level of process and operational optimization, and their implementation will be necessary in maintaining a competitive edge.

Marine fleets have been cautious about adopting digital services, whether due to perceived cost or lacking awareness of the possibilities. Nonetheless, they are becoming more common in support of traditional marine operations, and they are available today for SOx scrubbers.

In their most basic form, digital services are used for remote troubleshooting. However, much more is possible by actively collecting performance data and analysing it with smart algorithms. Data-driven digital services can support scrubber maintenance and operation in the areas of:

1. Compliance reporting
2. Service monitoring and support
3. Benchmarking and optimization

## Compliance reporting

Reporting SOx scrubber compliance can be a significant hassle. Digital services help simplify the process by automatically generating localized reports where all compliance values are shown graphically, as in Figure 2. When a vessel moves between compliance regions, the compliance limits are automatically adjusted. This means the reports can be handed over directly to regional authorities, without additional effort.



Example of a localized, graphical compliance report



## Service monitoring and support

Remote monitoring enables access to the SOx scrubber's diagnostic data from shore. This allows identification and analysis of the root causes of an alarm or system failure, which in some cases can be resolved directly. If parts are needed to correct the problem, they can be sent out immediately, while the vessel is still at sea.

Continuously collecting scrubber sensor data provides an active digital footprint of the scrubber's performance. Over time, the ever-growing set of data allows for detailed and complex analyses, performed automatically by clever algorithms. These algorithms can monitor the primary indicators of scrubber performance, namely the water flow, gas flow and pressure, which provide information about one of the main scrubber cost-driving factors: energy consumption.

Scrubber energy consumption is almost completely determined by the function of the scrubber pumps that move the water in the SOx scrubbing process. Poorly performing pumps will require more power to supply the right flow rate and pressure. The same is true for worn sprayers, which will make the pumps work harder to compensate for the pressure loss, thus consuming more energy and deteriorating faster.

Both pump deterioration and sprayer wear can be detected automatically by algorithms. Algorithms can indicate when sprayers in a certain layer must be replaced, for example, ensuring that replacement occurs when it is more economical than continued operation.

Similarly, algorithms can automatically indicate the need for maintenance actions, informing the crew as to which, where and when actions should be performed. Alternatively, threshold values can be set manually to trigger a flag or warning when reached.

## Benchmarking and optimization

Digital services also make it possible to benchmark and optimize system performance across multiple SOx scrubber systems. Scrubbers on connected vessels within a fleet can easily be compared in order to identify areas for improvement and cost-reducing optimization. Both maintenance and costs can be predicted and planned with greater accuracy and efficiency.



## Spare parts management

Spares and consumables form a relatively small share of SOx scrubber service and operational costs. However, the use of poor-quality parts or the lack of correct parts during a critical system failure can result in costly scrubber downtime. It is thus worthwhile to carefully consider a strategy for spare parts, balancing cost versus risk.

Some important questions are:

- Which parts are critical for the scrubber's operation?
- What are the costs and risks of scrubber downtime?
- Which parts are the main cost drivers?
- What parts does the service provider stock?
- What stock can or should be kept onboard?

In addition, it is important to consider the reliability and durability of spare parts. Non-original parts may be cheaper to purchase, but they usually have a more limited lifetime and may increase the risk of failure. The use of non-original parts may even void the scrubber's warranty.



## Definition of spares and consumables

When considering the need for spares and consumables, it is helpful to discuss and understand the provider's philosophy and definitions. For example, spares and consumables might be categorized in the following way:

### 1. Critical parts

These are parts essential for operation. Normal automatic operation of the system is difficult and time consuming, or impossible, when these parts are defective or malfunctioning. Detailed system knowledge is required to resolve the issue when such parts fail. Parts required by class or for class function are also seen as critical. Critical parts including actuators, sensors, bearings and fuses may need to be kept in dedicated stock or even on board.

### 2. Recommended parts

These are parts that are not immediately essential for successful operation. However, they might need to be temporarily repaired or bypassed in order to operate the system in the event of a failure. If a failing part is not replaced, the system may be operated in semi-automatic or manual control mode. Recommended parts include signal lights, push buttons, valves and displays, and having them available makes life easier.

### 3. Consumable parts

Being consumable, these are parts that need to be replaced after a certain period of use. They are used for preventive maintenance and maintaining the scrubber for a certain minimum period, e.g. two years. Understanding the provider's view of spares and consumables will help prevent misunderstandings when discussing which ones to purchase and stock.

# Service agreements

Having decided which external services are needed to support SOx scrubber use and operation, it can be worth considering a service agreement. A one-stop service provider will likely be able to offer tailor-made service plans, making it possible to match the specific needs of a vessel or fleet.

A service agreement typically comprises several hand-picked services, which are provided for an agreed period on a recurrent basis, e.g. annually or biennially. Ideally, the services are provided for a fixed yearly fee, which provides full control over maintenance costs.

Before entering into a service agreement, it is important to clearly define the expectations of each party, making sure that each understands the services and their benefits. As in the purchase of equipment, the specifications should be detailed in the contract. The agreed benefits can then be achieved through a mutual process of continuous improvement and collaboration.





## Conclusion

In order to safeguard compliance and operating economy, it is important to arrive at a SOx scrubber maintenance strategy that is suitable for the vessel or fleet. Beyond satisfying the maintenance needs prescribed by the scrubber supplier, the strategy should account for crew competence levels and the available budget. Just as importantly, it should reflect stakeholders' willingness to take on risk.

In most cases, stakeholders choose a combination of preventive and corrective actions, each of which has pros and cons. However, predictive maintenance with the help of data-driven digital services is the ideal in terms of optimizing maintenance actions and costs.

Choosing the right service provider involves evaluating all service offerings, including traditional field services and spare parts management. A service provider that can act as a partner, providing the full scope of needed scrubber services and ideally offering the security of a tailor-made service agreement, can provide valuable peace of mind in an application that is integral to vessel operations.

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