

Experiences with Scrubber Operation: Theory and Reality

IMO has limited the maximum sulphur content of fuel used onboard vessels. As of 1st of January 2020 the maximum sulphur content must not exceed 0,5% sulphur m/m on all ocean waters except in dedicated Sulphur Emission Controlled Areas (SECA) where only fuel with a sulphur content less than 0,1% m/m is permitted as determined in MARPOL Regulation Annex VI. However, the regulation allows the use of alternative compliance methods, i.e. scrubbers.

The first DeSOx scrubbers have been installed app. 15 years ago and since more than 3.600 scrubber systems are on order with app. more than 800 in operation. Open Loop systems dominate the market with more than 80% market share. Various sources predict 15.000 to 18.000 systems to be installed and operated by 2025.

Experiences gained during the last 10 years with the installation and operation of scrubbers showing room for improvements in various fields:

- Design data and layout (dimensioning)
- Material selection (tower body, pipes, pumps etc.) to avoid corrosion
- Operations (wet and dry running)

Of all scrubbers in operation only a few reported to not meet the requested SO₂/CO₂ ratio. In some cases, the alkalinity of the up taken sea water was too low to be compensated by more sea water due to limited sea water pump capacity. Other operational problems occurred due to high temperature of the up taken sea water.

Design and Layout

In a wet scrubber the exhaust gas delivered by the engine (sometime passed through an Exhaust Gas Boiler before entering the scrubber tower) has to be cooled down to saturation temperature in order to enable the physical and chemical processes to take place. Also, an almost even distribution of the exhaust gas across the diameter of the scrubber is important to achieve the desired results. After the desulphurization of the exhaust gas a demister and dedusting unit precipitates water droplets and particulate matter from the exhaust gas.

Typical design failures are:

- Calculation and layout of scrubber water consumption
 - Residence time
 - Contact surface
- Backpressure of scrubber system
- Insufficient precipitation of water droplets and particulate matter (carry over)

Material Selection

The specification of the tower material properties is extremely important as the tower has to withstand corrosive media like seawater, caustic soda, sulphuric acid and sulphur acid. In addition to this there is a high exposure to aggressive salts. Further the specified material must be resistant to high temperature up to 400°C in case of dry mode running. Therefore, the right selection of materials is essential for the durability and performance of the entire scrubber system.

Also, the material selection for the wash water pipes has to be carried out carefully. GRE and PE are the materials of choice in most of the applications. However, we recommend PE as the handling of the material is a lot easier as opposed to GRE which is a rather brittle material not resistant against torsion forces and mechanical stress. In no way carbon steel or mild steel should be used. Also, the overboard discharge pipe should be made of high-quality stainless steel.

The material of the pumps being operated in an Open Loop Scrubber System should be made of copper-aluminum-nickel alloy or nickel-aluminum-bronze for both casings and impellers. In Closed Loop Systems the material should be duplex steel like 1.4462 or 1.517.

Operations

Scrubbers are in operation since more than 70 years in various industries. However, More or less all of them are designed to operate in static loads as opposed to vessel scrubbers which need to react to dynamic load changes. Dynamic operation in this context means that there is more than just one design point that has to be considered. Unfortunately, the needed amount of wash water varies with the engine operation point.

A significant number of scrubbers in operation onboard are showing the following effects:

- Supercooling of exhaust (too low temperature at scrubber outlet)
- Higher consumption of seawater at low load compared to high load
- Wash water carry over

When changing from dry run mode to regular operation the scrubber tower is exposed to significant thermal stress as the deltaT can easily be as high as 300°C which means shock cooling when the scrubber pumps start to operate.

Summary

SOx Scrubber operated onboard of vessels are a reliable alternative to the use of compliant fuel and show relatively short pay back times. However, to get the most out of this investment it is important to choose wisely the scrubber supplier and the quality of the materials used in the scrubber system. A scrubber system is not an “off-the-shelf” product but tailor made to the specific needs of the vessel and its sailing profile.

The design, the material selection and the operating strategy (in combination with crew training) of the scrubber determines the economic aspects of the scrubber operation. Any failure in these areas will have a tremendous impact on the availability and compliant operation of the scrubber system.