THE COATING CHALLENGES POSED BY SCRUBBER SYSTEM INSTALLATION

Safinah Technical Information Paper

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Introduction

A series of international regulations have been introduced to reduce the negative impacts of shipping on air quality. Specifically, measures to reduce Sulphur oxide (SO_X) emissions from the use of heavy fuel oils. At the 70th session of the International Maritime Organization (IMO), Marine Environment Protection Committee (MEPC) (MEPC.280(70) [2]), held in October 2016, a decision was taken that by 2020 ships will only be allowed to burn fuel oil with a Sulphur content of no more than 0.5% and, no more than 0.1% in designated Emissions Control Areas (ECAs) (see MARPOL [3] Annex VI, Regulation 14.1.3). The carriage and burning of non-compliant fuel will be banned from March 2020 unless the ship is equipped with a SO_X scrubber.

The Market Response

At present there are two main emission abatement strategies available to ship owners:

- Switching from Heavy Fuel Oil (HFO) to Marine Gas Oil (MGO) or low sulphur HFO;
- Installation of an Exhaust Gas Cleaning System (EGCS, commonly termed an exhausted gas scrubber) to reduce sulphur content of emissions.

Research [4] indicates that by the end of 2020, 15% of the world fleet (by tonnage) will be fitted with scrubbers.

Why Choose Scrubbers

Several factors influence the selection of a SO_X abatement system: the cost of compliant low-sulphur fuels; the Capital Expenditure (CapEx) and Operational Expenditure (OpEx) of the scrubber and the amount of time that the ship is expected to stay within ECAs [5].

There is no need to install a scrubber if the ship is already operating on low Sulphur fuel and complying with emission rules. However, some ship owners may prefer to continue to run on cheaper high Sulphur fuel and incur the costs of installing and operating a scrubber. The potential Return on Investment (ROI) will depend on factors such as age of ship, price of fuel, operating profile and economics, trading areas etc.

Wet SOx Scrubbers

There are two types of SO_X scrubber systems; the dry-type and wet-type scrubbers. This Safinah TIP will focus on wet scrubbers because they are the most common type used at present, also current IMO Guidelines [6] are based on wet technologies (as

envisaged by the original Regulation 14.4 (b) to MARPOL Annex VI).

Wet systems can be categorised into three types: Open or Closed Loop and Hybrid.

- An Open Loop system uses seawater as washwater by directly connecting the piping system with the sea, and then discharging (acidic) washwater back directly into the sea. However, some ports and coastal states have implemented more stringent local regulations that restrict or prohibit the discharge of washwater from such Open Loop scrubbers.
- A Closed Loop system uses treated (alkaline) freshwater as the washwater which is internally circulated through a (re)circulating process tank. Small amounts of washwater can be discharged from a Closed Loop system, however the majority is stored in a holding tank which can enable a zero-discharge mode.
- A Hybrid system can be operated in either Open Loop or Closed Loop mode.

Table 1 below presents a comparison between the Open Loop, Closed Loop and Hybrid systems from technical and economic aspects [7, 8]. at present, the most popular scrubber type installed is the Open Loop (approximately 70% market share [9]), however more recently Hybrid options have dominated.

Potential coating challenges

On-board Washwater

The SO_X gas emitted from engine exhaust is water soluble. However, once dissolved it can form strong acids and react with the washwater. The washwater within a scrubber system can have a pH as low as 3 which can cause corrosion of the system and equipment [10]. This key issue must be considered during the specification and selection of materials and coatings for scrubber system to ensure it can meet this low pH challenge. Figures 1 and 2 show the main components of the Open and Closed Loop wet systems, respectively. Note that, by definition, a Hybrid system is a combination of both an Open Loop and a Closed Loop system and hence is not illustrated in this TIP.

Table 1: The advantages and disadvantages of the various wet scrubbers

Scrubbers	Advantages	Disadvantages	Application
Open Loop	• Uses seawater as the washwater for scrubbing exhaust gases, hence does not usually involve onboard storage or handling of hazardous substance, e.g. caustic soda • Comparatively simple system installation and operation compared to Closed Loop or Hybrid • CapEx and OpEx both lower than Closed Loop and Hybrid	• Limited emission abatement performance in low alkalinity seawater • Discharge of (acidic) washwater directly to the sea, therefore potentially harmful to a local ecosystem • Large washwater demand • Typically, higher operational power requirements than Closed Loop	• Suitable for ships predominantly operating in the open ocean • Ships not entering areas with washwater discharge restrictions
Closed Loop	• Can be operated in low alkalinity seawater • Limited/no water discharge into the sea which permits operation in discharge restricted coastal/port areas • Typically, lower operational power requirements than Open Loop	• More complex system with additional water treatment equipment than Open Loop • Shore supply and disposal needed • More space required than Open Loop • Handling and storage of hazardous substances • Operation duration limited by holding tank size • Relatively higher CapEx than Open Loop • Relatively higher OpEx than Open Loop due to use of NaOH and residue handling	• Ships trading predominantly in coastal areas with discharge restriction or low alkalinity water
Hybrid	• Flexibility to operate in all sea area regardless of seawater alkalinity or temperature • Discharge to sea can be limited as required	• Complex system • Shore supply and disposal needed • More space required • Handling and storage of hazardous substances • High CapEx • High OpEx due to use of NaOH and residue handling	• Ships predominantly operating in low alkalinity water • Ships operating in discharge/operation restricted areas

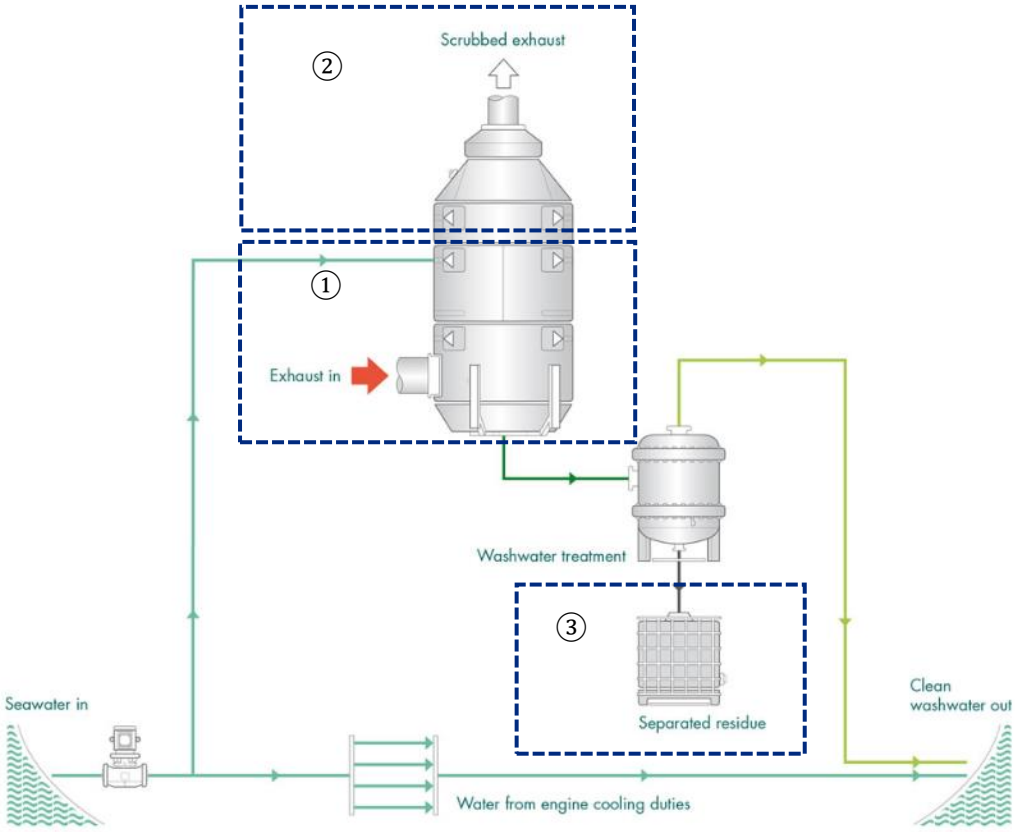

Figure 1: The Open Loop scrubber system [11]

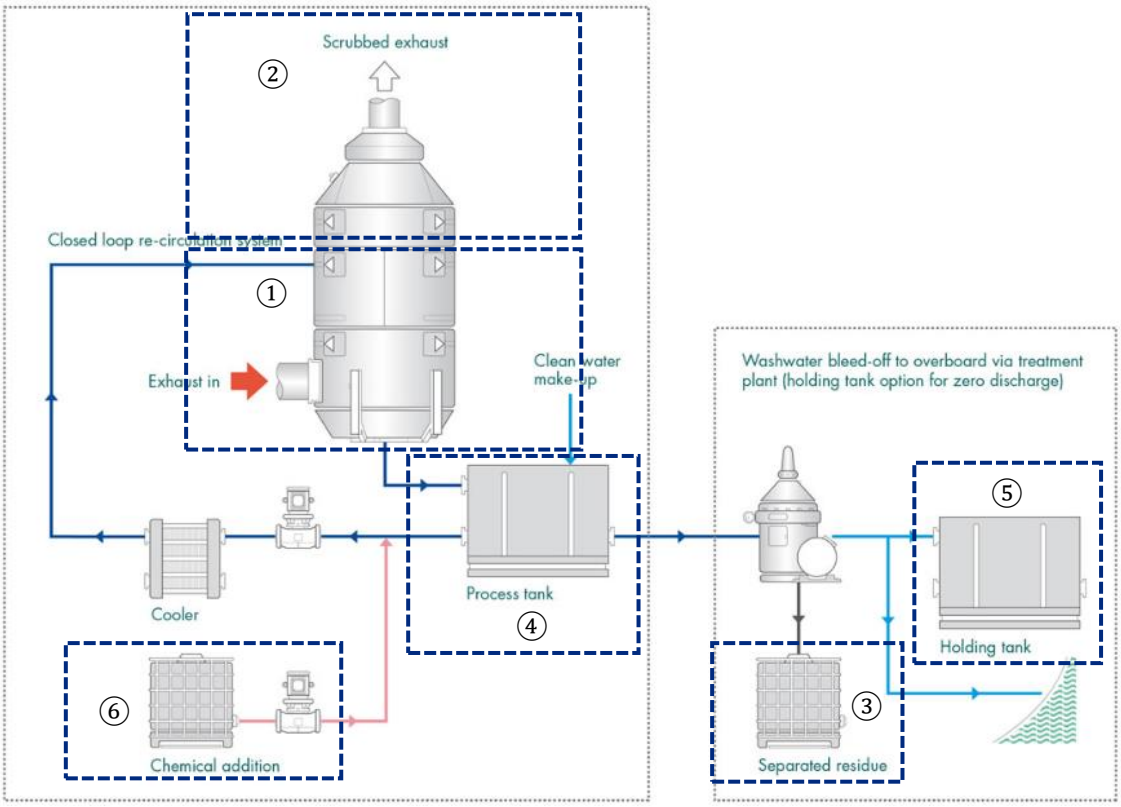

Figure 2: The Closed Loop scrubber system [11]

The key pH protection challenges for the various components and equipment within a wet scrubber system are discussed below:

- During the process of washing the engine exhaust gas, the sulphurous flow steam is introduced into the lower portion of the scrubber (see section 1 in Figures 1 and 2), whilst the washwater is injected as a spray. The acidic washwater flows down the wall to the bottom of the scrubber. Therefore, the lower interior surface of the scrubber is subjected to highly concentrated acidic washwater and acidic steam;
- The interior surface of the higher portion of the scrubber, i.e. exhaust gas outlet (see section 2 of both Figures 1 and 2), acidic conditions may exist to a lesser extent as scrubbers are not 100% efficient in removing SO_X;
- Residual sludge removed from the washwater is fed to a separated residue/sludge tank (see section 3 of both Figures 1 and 2) for disposal ashore. Therefore, highly acid corrosive environments are formed within all tanks and associated pipework and equipment;
- For a Closed Loop scrubber, the dirty washwater is fed to a process tank (See section 4 of Figure 2). Thus, highly acid corrosive environments are formed within all tanks and associated pipework and equipment;
- During either process, the cleaned bleed-off water is discharged overboard or fed to a holding tank (see section 5 of Figure 2) depending on operating location and local regulations. The bleed-off water usually has a lower pH and hence could cause corrosion damage to the tank and associated pipework and equipment together with overboard discharge area;
- In a Closed Loop system, the washwater is re-circulated and any losses made-up with additional freshwater mixed with alkaline chemicals provided from the alkali (Sodium hydroxide, NaOH) unit (see section 6 of Figure 2). The strong alkali environment can increase the risk of alkaline corrosion of the unit and associated pipework.

For a wet scrubber system, Table 2 overleaf gives further typical details on the pH and temperature values at each section of the system.

Table 2: pH and temperature variance by section within a wet scrubber

Section	pH variation	Operation Temperature
Scrubber	2.5	50℃– 60℃
Process Tank	5.0 – 7.0	45℃ – 50℃
Akali Unit	14.0	> 25% concentration 25℃ – 35℃
Washwater from Scrubber Hopper	2.5 – 8.4 (Open Loop) 5.5 – 8.0 (Closed Loop)	0℃ – 35℃ (Open Loop) 20℃ – 60℃ (Closed Loop)
Overboard Discharge Pipe	5.0 – 6.5	< 40℃
Sludge Tank	3.0 – 5.0 (Open Loop) 5.0 – 7.0 (Closed Loop)	45℃ – 50℃ (Open/Closed Loop)
Holding Tank	5.0 – 7.0	40℃– 45℃

Over-board Discharge Water

The IMO EGCS Guidelines [12], require the washwater to be neutralized and diluted with additional seawater in order to increase the pH level above 6.5 before discharge. Most scrubber system makers claim that as long as the washwater is properly monitored and hence treated, it should not cause problems. However, some recent announcements [13, 14] indicate that corrosion damage has been evident on some ships due to discharged washwater. It was found that the pipework associated with the discharge of washwater could become severely corroded. leading to an increase in repairs to corroded pipework and outlets, which [15].

United States Environmental Protection Agency [10], seawater scrubber trials indicated that attempts to neutralize acidic washwater could result in the discharge of washwater with pH values below 6.5. Other tests have also shown that discharge water can often be below the recommended value and so proper operation of these systems will be critical.

Antifouling performance concerns

IMO Guidelines for Exhaust Gas Cleaning Systems [12] require pH of discharge washwater to be equal to or greater than 6.5 at 4 meters from the discharge point when the ship is stationary.

For some antifouling coating system within 4 meters from the discharge point, the lower pH may have effects on performance. The binder existing in some biocidal antifouling systems is acidic and hence could react with alkaline seawater. Extreme pH changes either acidic or alkaline could therefore affect the antifouling performance.

Guidelines for Protective Coating Selection

Based on the above, it is important for a wet scrubber system that internal surfaces subject to a corrosive environment need to be protected from chemical corrosion by coatings with excellent chemical resistance properties. Accordingly, for both Open Loop and Closed Loop systems, Table 3 and Table 4 respectively list factors must be considered within in these key system areas during the selection of the coating system. However, the exact needs may vary from one scrubber system to another.

Table 3: Factors to be considered for Open Loop scrubber systems

Open Loop System	
Key Areas	**Factors to be considered**
Seawater supply pipe	• Anti-corrosion
Discharge pipe and the shell area around its outlet	• Acid-resistant • Anti-corrosion
Exhaust pipe	• Highly chemical corrosion resistant • Acid-resistant • High temperature performance
Sludge pipe	• Acid-resistant • Anti-corrosion
Residue tank	• Acid-resistant • Anti-corrosion

Table 4: Factors to be considered for Closed Loop scrubber system

Closed Loop System	
Key Areas	**Factors to be considered**
Freshwater/seawater supply pipe	• Anti-aqueous corrosion • Highly chemical corrosion resistant
Discharge pipe and the shell area around its outlet	• Acid-resistant • Anti-corrosion
Exhaust pipe	• Highly chemical corrosion resistant • Acid-resistant • High temperature performance
Sludge pipe	• Acid-resistant • Anti-corrosion
Washwater process tank	• Chemical-resistant • High temperature performance • Anti-corrosion
Bleed-off washwater holding tank	• Acid-resistant • Anti-corrosion
Akali unit	• Highly chemical corrosion resistant • High temperature performance
Residue tank	• Acid-resistant • Anti-corrosion

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