Damage of SOx Scrubber Discharge Water Lines

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1. INTRODUCTION

Regulation 14 of Annex VI of the MARPOL Convention gradually strengthens regulation of the sulfur content in fuel oil used on board ships. However, under Regulation 4 of the Convention, the use of fuel oil with a sulfur content exceeding the regulatory value is permitted if the ship is equipped with an exhaust gas cleaning system (SOx scrubber) approved by the flag government as an equivalent measure to the use of fuel oil with a low sulfur content that complies with the regulation (compliant fuel). Since the limit for open sea areas was reduced from 3.50 % to 0.50 % in 2020, not only use of a compliant fuel, but also installation of a SOx scrubber has been considered and adopted as a response. Under these circumstances, as the number of vessels equipped with SOx scrubbers has increased, ClassNK (hereinafter, the Society) received several reports of seawater leakage from corrosion-damaged distance pieces fitted to hull structures on SOx scrubber discharge water lines. Although the Society issued technical information (TEC-1205 and 1214) in 2020 on measures to prevent this type of damage, similar incidents are still being reported. Therefore, we are publishing this Technical Journal article to share the results of statistical evaluations of the factors presumed to be responsible for this damage and the countermeasures to be taken.

2. OVERVIEW

SOx scrubbers remove the sulfur content from exhaust gas by spraying the exhaust gas with washwater. In open type SOx scrubbers, which are widely used, the washwater sprayed in the SOx scrubber tower reacts with the exhaust gas and is discharged overboard.

According to the damage reports received to date, seawater leakage has been observed either on or adjacent to welded parts between distance pieces and their associated flanges (see Fig. 2), as well as between distance pieces and bluff bodies (see Figs. 3 and 4), as shown in Fig. 1. These reports indicate that the corrosion apparently initiates at welded parts and then continues to progress until it finally leads to seawater leakage into the engine room. Peeling of the painted surfaces of butt-welded parts of distance pieces (see Fig. 5) has also been observed.

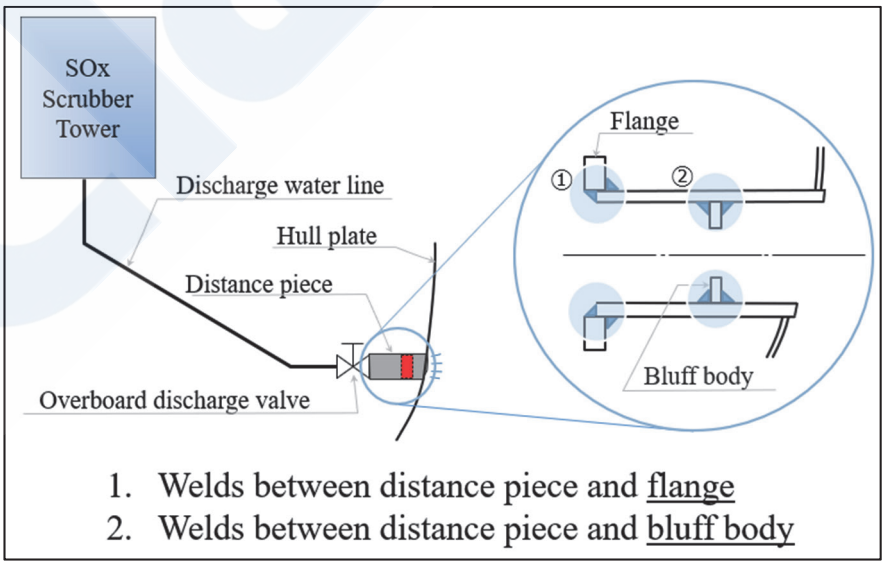

Fig. 1 Schematic of SOx scrubber discharge water system

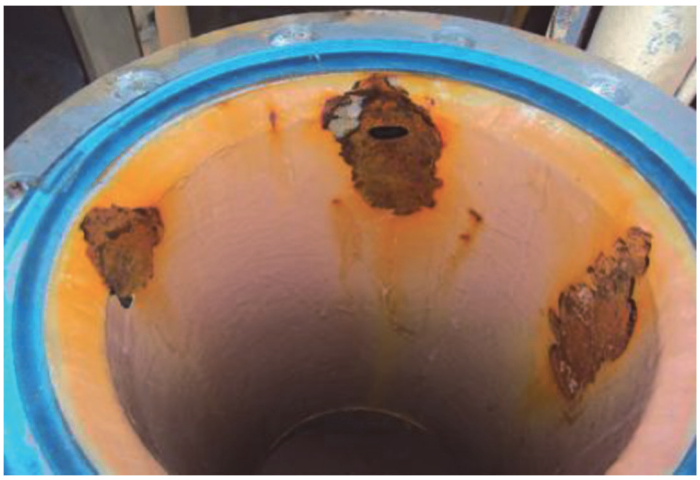

Fig. 2　Corrosion around welded parts between distance piece and flange

Fig. 3　Corrosion around welded parts between distance piece and bluff body

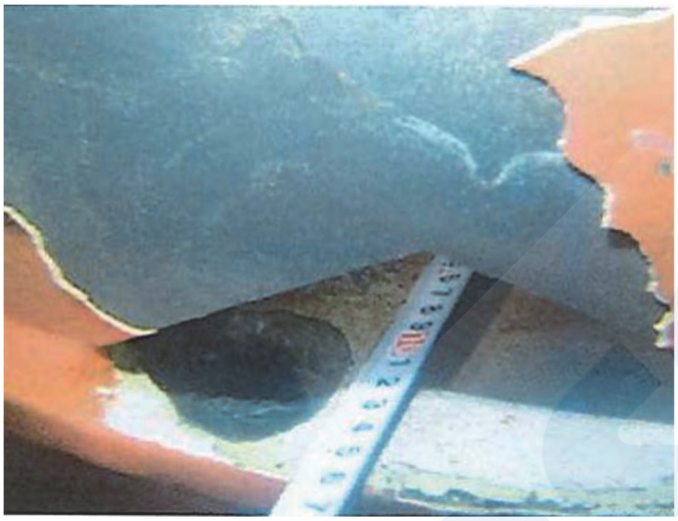

Fig. 4　Corrosion around welded parts between distance piece and bluff body

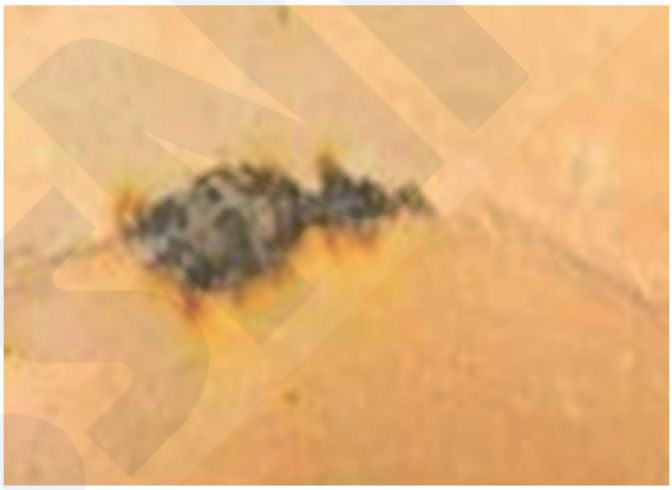

Fig. 5　Paint peeling at butt-welded parts of distance piece of discharge water system

3.　POSSIBLE CAUSES

The following is a list of the possible causes estimated since this damage became apparent, based on the nature of the SOx scrubber system and the trends of damage cases reported to the Society.

3.1　Acidity (pH) of Discharge Water

During the desulfurization process in the SOx scrubber tower, the sulfur content in the exhaust gas is dissolved in the sprayed washwater and discharged overboard. Therefore, discharge water with a high acidity of pH 3 to 4 may flow through the distance piece on SOx scrubber discharge water lines, depending on the amount of washwater and the desulfurization performance of the SOx scrubber. Although corrosion-resistant paint is generally applied to the inner surface of the distance piece, corrosion is thought to occur in areas where the paint has peeled off and the distance piece is directly exposed to the highly acidic discharge water.

3.2　Flow Velocity of Discharge Water

In order to satisfy the regulatory value for the sulfur content in exhaust gas, it is necessary to remove the sulfur content sufficiently from the exhaust gas by spraying a large amount of washwater in the SOx scrubber tower. When a large amount of washwater is sprayed, it is presumed that the distance piece on SOx scrubber discharge water lines will become less corrosive due to the decreased acidity of the discharge water after the exhaust gas is cleaned. On the other hand, the flow velocity of the discharge water increases because of the large amount of washwater and discharge water. This increase in the flow velocity

could be an environmental factor that facilitates paint peeling.

3.3 Bluff Body

Based on the EGCS guideline established by IMO (Resolution MEPC.340(77)), the pH of discharge water after exhaust gas cleaning must recover to 6.5 or higher in seawater 4 m from the overboard discharge port. To meet this standard, some SOx scrubber manufacturers install a bluff body in the distance piece on SOx scrubber discharge water lines to diffuse the discharge water so it is more easily diluted by the seawater outside the vessel. If a bluff body is installed, the connection between the distance piece and the bluff body will be narrower, which is expected to worsen workability in terms of space. This suggests that the quality of welding and painting work could deteriorate, resulting in a condition in which the paint is easily peeled off. In addition, the bluff body decreases the cross-sectional area where discharge water passes, which causes a sudden increase in the flow velocity of the discharge water and a turbulence flow, which is assumed to result in easier peeling of the paint on the distance piece.

3.4 Installation Environment

When SOx scrubbers are retrofitted after ships enter service, the time available for installation is limited compared to installation during newbuilding, and for this reason, it is assumed that workers may not fully comply with the installation procedures specified by the paint manufacturer to prevent corrosion of the distance piece.

In addition, in a retrofit facility environment, it may be difficult for workers to install the equipment with sufficient quality because of the small workspace and unstable scaffolding.

Recently, in many cases, measures such as dispatching a site supervisor or a professional engineer for SOx scrubber installation have been taken at the time of retrofitting to ensure sufficient installation quality. However, in the early stages of SOx scrubber adoption, it is highly possible that the quality of the painting work was not sufficient because the importance of painting quality was not recognized, or because a site supervisor could not be dispatched due to COVID19.

Especially, the painting work at the edge of the surface, where the paint is applied in a linear pattern or in dots as though with a stylus as a finishing touch, may result in a decrease in the adhesion of the paint. Therefore, the painting work at these areas should be done with the utmost care.

3.5 Solid Substances

Seawater is generally used as the washwater sprayed in SOx scrubber towers, and there have been reports of solid substances caused by salt from the sprayed seawater accumulating in the SOx scrubber tower and exhaust gas pipes. When solids occur, they are eventually discharged overboard, but may cause physical damage to the inner surface of the distance piece on SOx scrubber discharge water lines.

4. DATA ON FLOW VELOCITY AND ACIDITY OF DISCHARGE WATER

Fig. 6 shows the relationship between the data on the flow velocity and pH of discharge water and the presence of damage on vessels equipped with SOx scrubbers in ClassNK vessels. These data were extracted from a population of damage cases reported to the Society and cases in which no damage occurred, so there is no bias among SOx scrubber manufacturers. The data for the percentage of damaged vessels per flow velocity range show that the percentage of damaged vessels increases as the flow velocity increases (from 24 % to 67 %). However, there were cases where damage occurred even though the flow velocity was low, and conversely, cases where damage did not occur even though the flow velocity was high (the same was true for pH), suggesting that damage was not caused by one factor alone, but by a combination of several factors.

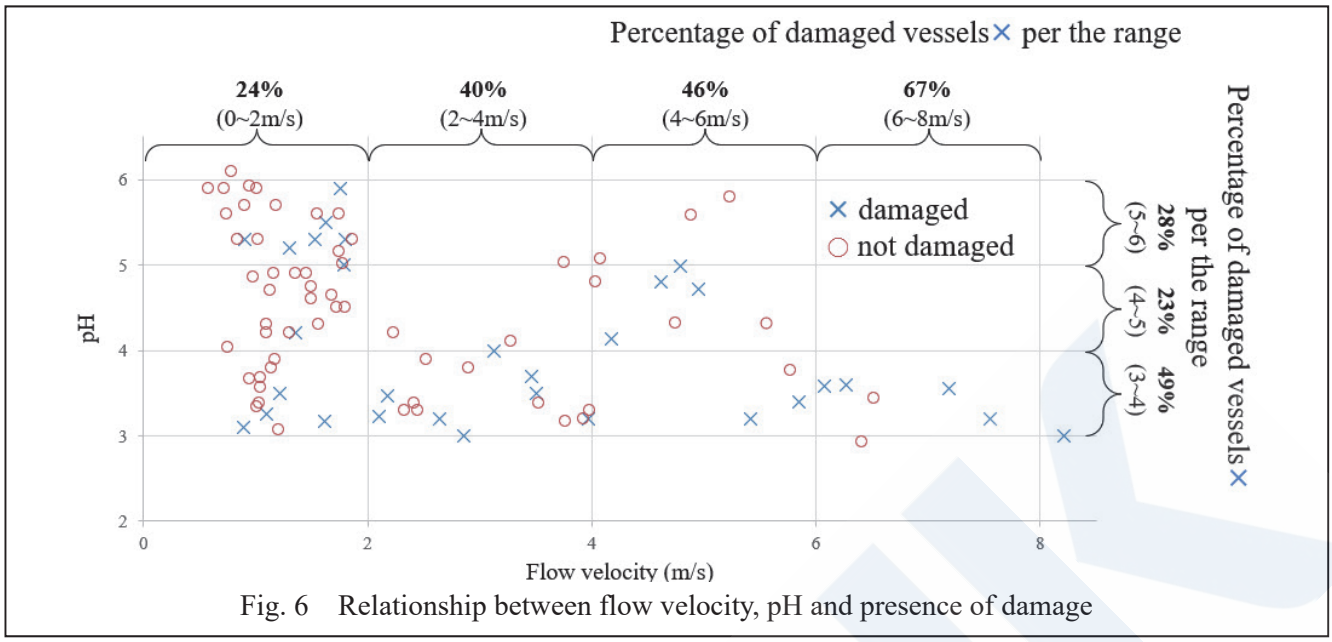

Fig. 6　Relationship between flow velocity, pH and presence of damage

5.　STATISTICAL TEST

Based on our investigations, the following factors have been postulated as causes of the damage to distance pieces: (1) acidity (pH) of discharge water, (2) flow velocity of discharge water, (3) bluff body, (4) installation environment and (5) solid substances. However, since it was found that this damage was not uniformly caused by a specific factor, the above-mentioned factors should be considered to be only intuitive estimation factors.

Therefore, the following factors (1) to (4) were compared in the damaged and non-damaged groups to determine whether any statistically significant differences existed by using statistical tests (i.e., a significant difference test) from the data of ClassNK vessels, and the relationship between those factors and the damage was investigated. The results showed that there are some statistical relationships between these factors and this type of damage, as shown below.

(1) Acidity of discharge water (pH)*
　There is a significant difference. More damage occurs as the pH increases.
(2) Flow velocity of discharge water*
　There is a significant difference. More damage occurs as the flow velocity increases.
(3) Presence of bluff body**
　There is a significant difference. More damage occurs when bluff bodies are present than when bluff bodies are absent.
(4) Installation environment (i.e., whether the scrubber was installed during newbuilding or during retrofitting after the ship entered service)**
　There is a significant difference. Vessels that are retrofitted with scrubbers after entering service are more likely to be damaged than those in which scrubbers are installed at the time of newbuilding.

*　Based on t-test: Test method to determine if there is a significant difference in the relevant subjects for each population.
**　Based on $\chi 2$ (chi-square) test: Test method to determine if there is a significant difference between the observed and expected values.

(Supplementary information)
Generally, a statistically significant difference is considered to exist if the criterion value (p value) is less than 0.05. The values of each of the above-mentioned items were as follows; (1) p=0.0110 (2) p=0.0027 (3) p=0.0300 (4) p=0.0008. This study did not consider the effects of the condition of the paint, the type of paint or the shape of the bluff body.

6. COUNTERMEASURES

These results suggest that measures which take these factors into account may reduce the risk of damage. The following are the advantages, disadvantages and points to note about the measures that are currently considered effective. It should be noted that the following measures are for reference purposes only, and their effectiveness is not guaranteed in all cases. Therefore, you are requested to independently investigate their effectiveness on a case-by-case basis and study their applicability carefully with the concerned parties when such measures are to be applied.

6.1 Paint

If an appropriate corrosion-resistant paint is applied and the installation quality is adequate, painting is considered to be sufficiently effective as a corrosion countermeasure. In order to prevent corrosion due to inadequate painting quality, it is important to pay special attention to pre-painting procedures and paint application, and to ensure that the procedures specified or recommended by the paint manufacturer are followed.

6.2 GRE Lining

Linings made of GRE (Glass fiber Reinforced Epoxy) or GRVE (Glass fiber Reinforced Vinyl Ester) have excellent corrosion resistance, and can be expected to provide pinhole-less performance. However, GRE or GRVE lining requires a certain construction period because the lining material must be dried repeatedly. In addition, as in the case of paint, sufficient attention should be paid to quality control at the installation site.

A GRE sleeve is also adopted in some cases to solve the problems of drying time and installation quality. In this case, the GRE is formed into a sleeve in advance at the manufacturing factory prior to the installation on board, and the sleeve is inserted inside the distance piece and bonded with a special paint on board.

6.3 Stainless Steel Pipe

When stainless steel is used as the material of the distance piece, the risk of corrosion is considered to be less affected by installation quality because the pipe itself has high corrosion resistance.

However, because the hull plates will be made of a different material than the distance piece, appropriate painting or other measures to prevent electrolytic corrosion will be required. If stainless steel is used, it should be noted that approval of the welding procedure specification for stainless steel is required.

6.4 Change of Bluff Body Shape

If the shape of the obstruction plate installed on the distance piece is changed from a bluff body to an orifice type, the workability around the installation area will be improved, and as a result, the quality of welding and painting work will be improved, and the risk of corrosion occurring around the point will be reduced. However, when the shape of the bluff body is changed, recalculation by CFD or other means is required to confirm that the pH standard of the discharge water specified in Section 3.3 is satisfied.

7. CONCLUSION

The authors believe that the information contained in this Technical Journal article will be a useful reference for shipowners, ship management companies, etc., and will make it possible to take effective preventive actions as needed.

We recommend that shipowners and ship management companies share the above-mentioned information with the ship masters of vessels on which SOx scrubbers are installed, and instruct them to pay greater attention to external inspections of discharge water lines (especially those around distance pieces from engine rooms) and carry out the said periodical inspections more frequently, and also arrange to inspect the internals of distance pieces when the opportunity presents itself, e.g., by arranging divers for hull cleaning.

We will continue to contribute to the safe operation of ships and the preservation of the marine environment by actively collecting and disseminating information to those concerned.