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Corrosion Prevention and Control for Marine Scrubbers

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Foreword

Regulations of diesel exhaust are limiting emissions of sulfur oxides and particulates from ships burning heavy fuel oil. In January 2020, the global 0.5 per cent sulfur cap was enforced and around 4,000 ships have been fitted with exhaust gas cleaning systems (scrubbers). There are over 94,000 vessels in the world, according to the United Nations Conference on Trade and Development (UNCTAD)[1] ranging from cruise ships to container carriers and oil tankers, military, and other smaller vessels. Although other options are available, the preferred compliance method is the installation of wet scrubber systems because they are more cost effective. Other options for compliance are low sulfur fuel oil (LSFO), most expensive, blended fuels, and alternative fuels (liquified natural gas [LNG], liquified propane gas [LPG], hydrogen, batteries).

This Technical Report provides sound technical information on the corrosion risk of exhaust gas scrubbers to ship owners, shipyards, marine engineers, scrubber designers and suppliers. Marine scrubbers used on ships are mainly wet scrubbers, which are open-loop, closed-loop, or hybrid types. Each system is discussed with respect to a description of each type of scrubber, washwater environments, materials of construction (metals and non-metals), pitfalls of inspection, fabrication, and welding of metals, service performance and applications history including descriptions of corrosion failures and successes, and repair and maintenance guidance.

The results of this study are remarkable. Marine (seawater) scrubber environments are not as corrosive as land-based limestone scrubber systems. This conclusion is based upon the fact that the supersaturation of seawater with calcium carbonate results in little, if any, insoluble sulfates forming. This means that the marine scrubber tower environments will be less aggressive than those found in land-based limestone scrubbers, where severe corrosion has been seen under calcium sulfate deposits. For this reason, duplex, superduplex, and 6% Mo superaustenitic stainless steels have been used extensively and successfully for the last 10 years. C-276 variant alloys are preferred for hot, inlet tower piping, and fiberglass reinforced plastic (FRP) for cooler washwater piping. 7% superaustenitic stainless steels, alloy C-type high Cr-Mo nickel alloys, and titanium alloys were identified as alternate materials of construction for marine scrubbers.

AMPP technical reports are intended to convey technical information or state-of-the-art knowledge regarding corrosion. In many cases, they discuss specific applications of corrosion mitigation technology, whether considered successful or not. Statements used to convey this information are factual and are provided to the reader as input and guidance for consideration when applying this technology in the future. However, these statements are not intended to be requirements or recommendations for general application of this technology, and must not be construed as such.

[1] United Nations Conference on Trade and Development (UNCTAD), Palais des Nations, 8-14, Av. de la Paix, 1211 Geneva 10, Switzerland, unctad.org.

Section 1: Introduction

AMPP continues to support the maritime industry by conducting a state-of-the-art survey on the corrosion of exhaust gas cleaning systems (EGCS) or scrubbers on ships. The ultimate objective of this study is to provide sound technical information on the corrosion risk of exhaust gas scrubbers to ship owners, shipyards, marine engineers, scrubber designers and suppliers. AMPP's objective was to gather information and data on existing materials of construction, service conditions, performance history, and corrosion failures and successes. With 40 years' worth of information in AMPP's technical literature, the lessons learned continue to be gleaned from land-based flue-gas desulfurization (FGD) systems. This knowledge base on scrubber corrosion will help to ensure that similar problems or failures do not happen at sea. To expand its knowledge base, AMPP produced this technical report on Corrosion Prevention and Control for Marine Scrubbers.

Section 2: Background

MARPOL Annex VI Regulation 14[1] places limits on the sulfur content of marine fuel oils to control sulfur oxides (SOx) and particulate matter emissions, which requires the sulfur content of any fuel oil used on board ships not to exceed 0.5% globally on and after 1 January 2020.[2] The maximum sulfur content was 3.5% before 1 January 2020. This affects around 52,000 merchant ships trading internationally as of January 2019. The worldwide average sulfur content of residual fuel oil supplied for use on board ships is monitored as required by guidelines in IMO[(2)] Resolution MEPC.192(61),[3] as amended by IMO resolution MEPC.273(69).[4]

After 1 January 2015, the sulfur content of fuel oil used by ships operating within an emission control area was not permitted to exceed 0.10% m/m. Emission control areas include the Baltic Sea area, the North American area (within 200 nautical miles of the coast of North America), the Caribbean Sea area and any other sea area, including any port area, designated by IMO criteria or by local regulations.

As an alternative to the sulfur-in-fuel limits shown above, approved Exhaust Gas Cleaning Systems (EGCS), such as SOx scrubbers, can be used, as permitted through MARPOL Annex VI Regulation 4 in association with any applicable IMO Guidelines for the use of EGCS.[5] This is an alternative method of compliance with MARPOL Annex VI Regulation 14. The current applicable Guidelines for SOx EGCS are IMO Resolution MEPC.259(68), "2015 Guidelines for Exhaust Gas Cleaning Systems,"[6] in which the exhaust gas emission testing, EGCS approval, survey and certification, are regulated. Acceptance of an EGCS installed onboard any vessel is subject to approval by the flag administration of the vessel.

Scrubbers or EGCS are to be installed onboard a ship to remove particulate matter and harmful components, such as sulfur oxides (SOx) and polycyclic aromatic hydrocarbons (PAH) from the exhaust gases generated by the combustion processes in marine engines. These scrubbing systems have been developed and employed to treat exhaust gas from engines and auxiliary engines onboard marine vessels, to reduce such harmful components for compliance with MARPOL Annex VI. Due to the large reduction of the sulfur content limit from 3.5% to 0.5% for fuel oil used on board of ships since 1 January 2020, the limit for SOx content for SOx scrubbers is also reduced accordingly. This requires much higher performance from the scrubbers used on board ships.

Scrubber performance depends on many factors and scrubber manufacturers have extensive databases regarding the performance of their commercial brands of scrubbers for removing pollutants from different types of industrial sources. For better corrosion prevention and control, this report provides detailed information on the types of scrubbers used, performance factors, considerations for materials of scrubber construction, operation service performance history, and information on scrubber's installation, maintenance, and inspection.

As of January 2019, the top five ship-owning economies combined accounted for 51 per cent of world fleet tonnage. Greece held a market share of 18%, followed by Japan (11%), China (11%), Singapore (6%), and Hong Kong SAR (5%). Almost half of the world's tonnage was owned by Asian companies. Owners from Europe accounted for 41% and from North America for 6%. Companies from Latin America and the Caribbean, Africa and Oceania had shares of 1% or less.

[(2)] International Maritime Organization (IMO), 4, Albert Embankment, London, SE1 7SR, UK, www.imo.org.