

Recommendations for Material Selection and Welding for Optimum Corrosion Resistance in Washwater Discharge Stub Pipe in Marine Exhaust Gas Cleaning Systems (Scrubbers)

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Document History:

2023-12-11: Approved by AMPP Standards Committee (SC) 06, Process Industries

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AMPP SP21541-2023

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Foreword

This AMPP standard practice provides information for the material selection and welding procedures needed for optimum corrosion resistance of washwater discharge stub pipe in marine exhaust gas cleaning systems (EGCS, also known as scrubbers). The intended audience of the standard is shipyards, scrubber system manufacturers, installers, marine engineering firms, classification societies, flag state representatives (e.g., U.S. Coast Guard), ship owners, and ship operators.

A failure of a ship's scrubber can pose a risk to the health and safety of the public and personnel on the ship and to the marine environment. In AMPP Technical Report TR21448-2021, the coated carbon steel discharge stub pipe component located between the scrubber overboard valve and the ship's hull was identified as the most common type of corrosion failure in the scrubber system. This mode of failure can result in seawater flooding the engine room and shutting down the ship's engines. The engine room flooding problem has been reported recently for three ships with corroded EGCS.

Only in sections containing information about which there is general agreement among users are specific recommendations made. This standard is intended to assist engineers and operations and maintenance personnel in the shipping industry who participate in the design, modification, and maintenance of washwater discharge stub pipes.

The Project Team was composed of industry representatives from ship owners/operators, alloy suppliers, and consulting firms.

WARNING — The alloys selected using this document are resistant to the washwater discharge environments in seawater but are not necessarily immune to corrosion under all service conditions. It is the scrubber user's responsibility to select the alloys suitable for the intended service.

Scope

This standard addresses material selection and welding procedures needed for optimum corrosion resistance for marine exhaust gas cleaning system washwater discharge piping.

Rationale

Before the publication of this standard, there was no uniform, industry-wide standard for handling acidic washwater in the discharge stub pipe of marine exhaust gas cleaning systems. The primary purpose of this standard is to provide information allowing the reader to make a more informed decision regarding the selection of materials and provide information on appropriate welding of alloy stub pipes. Only in sections containing information about which there is general agreement among users are specific recommendations made. This standard is intended to assist engineers and operations and maintenance personnel in the shipping industry who participate in the design, modification, and maintenance of washwater discharge stub pipes.

Referenced Standards and Other Consensus Documents

Unless specifically dated, the latest edition, revision, or amendment of the documents listed in the table below shall apply.

AMPP/NACE/SSPC, www.ampp.org:

ANSI/NACE MR0175/ISO 15156	Petroleum and Natural Gas Industries — Materials for Use in H ₂ S-containing Environments in Oil and Gas Production
NACE/ASTM G193	Standard Terminology and Acronyms Relating to Corrosion
AMPP TR21448	Corrosion Prevention and Control for Marine Scrubbers
NACE SP0292	Installation of Thin Metallic Wallpaper Lining in Air Pollution Control and Other Process Equipment

American Society of Mechanical Engineers (ASME), www.asme.org:

ASME BPVC	Boiler and Pressure Vessel Code
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ASTM International, www.astm.org:

ASTM G71-81	Standard Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes
ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A262	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A264	Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate
ASTM A265	Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate
ASTM A380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM A923	Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
ASTM E165	Standard Practice for Liquid Penetrant Testing for General Industry
ASTM F722	Standard Specification for Welded Joints for Shipboard Piping Systems
ASTM F994	Standard Specification for Design and Installation of Overboard Discharge Hull Penetration Connections
ASTM F1155	Standard Practice for Selection and Application of Piping System Materials
ASTM F1173	Standard Specification for Thermosetting Resin Fiberglass Pipe Systems to Be Used for Marine Applications
ASTM G28	Standard Test Methods for Detecting Susceptibility to Intergranular Corrosion in Wrought, Nickel-Rich, Chromium-Bearing Alloys
ASTM G48	Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution

American Welding Society, (AWS), www.aws.org:

AWS A5.1	Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
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AWS A5.4	Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
AWS A5.9	Specification for Bare Stainless Steel Welding Electrodes and Rods
AWS A5.11	Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
AWS A5.14	Specification for Nickel and Nickel- Alloy Bare Welding Electrodes and Rods
AWS A5.17	Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.18	Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS A5.20	Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
AWS A5.22	Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding
AWS A5.34	Specification for Nickel Alloy Flux Cored and Metal Cored Welding Electrodes
AWS B2.1	Specification for Welding Procedure and Performance Qualification
AWS D1.6	Structural Welding Code — Stainless Steel

International Organization for Standardization (ISO), www.iso.org:

ISO 17781	Petroleum, petrochemical and natural gas industries - Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels
ISO 14172	Welding consumables — Covered electrodes for manual metal arc welding of nickel and nickel alloys — Classification
ISO 18274	Welding consumables — Solid wire electrodes, solid strip electrodes, solid wires and solid rods for fusion welding of nickel and nickel alloys — Classification

Standards Norway, www.standard.no:

NORSOK M-630	Material data sheets and element data sheets for piping
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In AMPP standards, the terms *shall* and *must* are used to state requirements and are considered mandatory. The term *should* is used to state something that is recommended but is not considered mandatory. The term *may* is used to state something considered optional.

Section 1: General

- 1.1** MARPOL Annex VI Regulation 14¹ places limits on the sulfur content of marine fuel oils to control sulfur oxides (SO_x) 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 Resolution MEPC.192(61),³ as amended by IMO resolution MEPC.273(69).⁴

- 1.2** As an alternative to the sulfur-in-fuel limits shown above, approved Exhaust Gas Cleaning Systems (EGCS), such as marine 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 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.
- 1.3** Marine scrubbers or EGCS are to be installed onboard a ship to remove particulate matter and harmful components, such as sulfur oxides (SO_x), nitrogen oxides (NO_x), 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 onboard ships since 1 January 2020, the limit for SO_x content for SO_x scrubbers is also reduced accordingly. This requires much higher performance from the scrubbers used onboard ships.

Figure 1 shows the location of a discharge stub pipe component in a typical marine scrubber system.

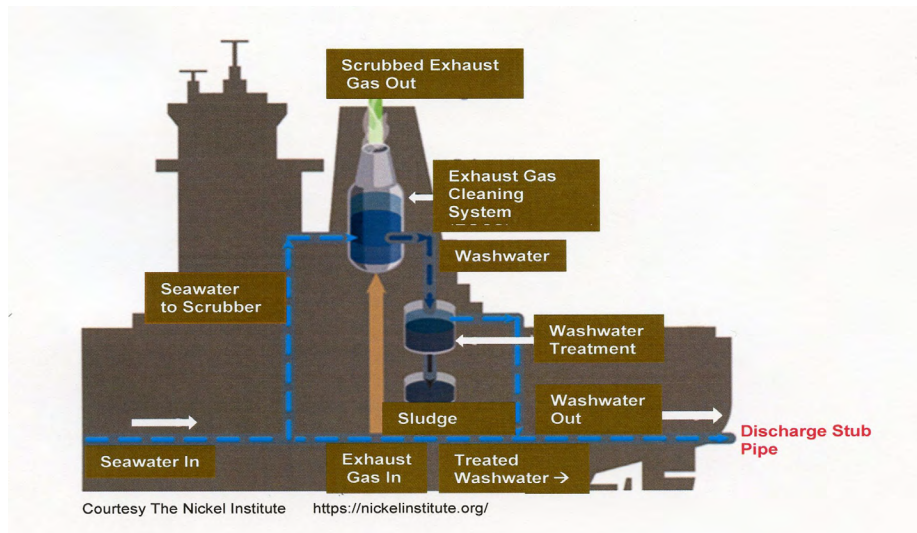


Figure 1: Typical Open Loop Scrubber System

- 1.4** Corroded carbon steel discharge stub pipes are a major corrosion problem for marine scrubbers, an example is shown in Figure 2. A discharge stub pipe being removed from the hull of a ship is shown in Figure 3. An example of a new discharge stub pipe ready for installation is shown in Figure 4. Figure 5 shows a view of discharge pipes exiting a ship's hull. Note the protective marine coating system and CP system (zinc anodes) on the ship's carbon steel hull in Figure 6.



Courtesy Hydrex (www.hydrex.be)

Figure 2: Corroded Carbon Steel Discharge Pipe – Before Cleaning



Courtesy Hydrex (www.hydrex.be)

Figure 3: Removal of a Corroded Discharge Stub Pipe from the Hull of a Ship



Courtesy Hydrex (www.hydrex.be)

Figure 4: A New Discharge Stub Pipe Installed in a Ship Ready for Service



Courtesy Yara Marine Technologies (www.yaramarine.com)

Figure 5: Discharge Stub Pipe Exiting Hull with UNS⁽¹⁾ S31254 Pipe Welded with Alloy 625, and Alloy 625 Weld Overlay (Cladding) around the Washwater Discharge Outlet



Courtesy Wencon (www.wencon.com)

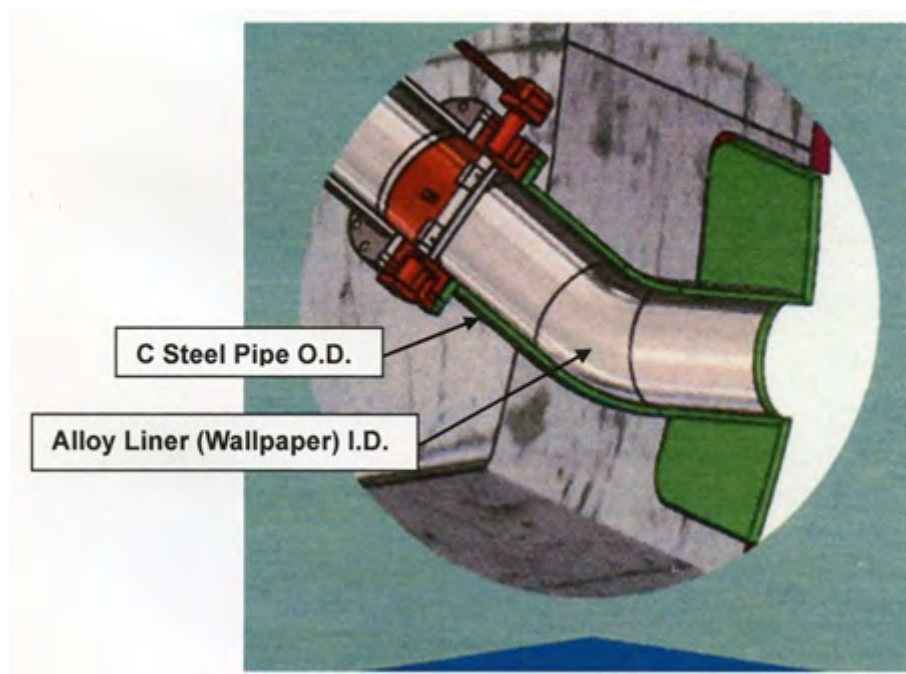
Figure 6: Discharge Stub Pipe Exiting Hull with Marine Coating System and CP System (Zinc Anodes)

⁽¹⁾ Unified Numbering System for Metals and Alloys (UNS). UNS numbers are listed in *Metals & Alloys in the Unified Numbering System*, 14th ed. (Warrendale, PA: SAE International and West Conshohocken, PA: ASTM International, 2023).

1.5 Possible candidate repair methods for corroded carbon steel discharge stub pipes include, but are not limited to:

Note: Some stub pipe repair/replacement concepts may be patented by fabricators or ship owners.

- Alloy Liner (Figure 7-A) - 1.5 mm thin sheet of CRA lining (wallpaper) attached (welded) to existing corroded steel stub discharge pipe.
-
- Double Containment (Figure 7-B) – CRA or FRP pipe inserted into a new steel stub discharge pipe.
-
- Cladding - 1.5 mm CRA cladding roll-bonded to steel plate and fabricated into a new clad steel stub discharge pipe.
-
- Weld Overlay - CRA filler metal welded in three passes onto the ID of a new or existing (repaired) steel stub discharge pipe.
-
- Laser welding - CRA filler metal laser welded in three passes onto the ID of a new steel stub discharge pipe.



Courtesy Wärtsilä Underwater Services (www.wartsila.com)

Figure 7-A: Alloy Liner