# Durability Report
# (Material Selection Philosophy)

## $CO_2$ Capture Facility

## Kårstø, Norway

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# Contents

# Durability Report

## 1.0 PURPOSE

The purpose of this document is to outline the philosophy employed in specifying metallic materials of construction and paint/coating materials for equipment and piping for the Karsto CCC Project.

## 2.0 DESCRIPTION

It is the intention of the Norwegian Government to develop a carbon dioxide capture and compression (CCC) project in association with an existing 420 MW gas-fired combined cycle power plant (CCPP), which is located in Kårstø, Norway.

The CCC facility will recover at least 85% of the CO2 contained in the flue gas from the CCPP and deliver liquefied CO2 to the battery limit of the facility. This is a new, proposed process plant to be located within an existing facility.

## 3.0 SCOPE

This document describes the materials selection and corrosion control philosophies that were used in selecting materials of construction for items of equipment and piping and coating materials to protect these components from degradation in the marine environment.

## 4.0 Materials of Construction

### 4.1 Amine Service

The specific metallic materials of construction for equipment and piping in amine service will be dependent upon the specific Amine chosen to selectively remove $CO_2$ and the design temperature/pressure conditions that are necessary in the process to optimize amine performance.

For this particular project Type 304/304L SS was selected as the minimum required material of construction for all items of equipment and piping in amine service. Depending upon the specific amine, for example MEA or DEA, carbon steel materials with post-weld heat treatment (PWHT) and specified corrosion allowances can also be used. But even with these amines, stainless steel material is often required for the rich-amine service portion of the process, depending upon temperature and amine loading. To provide maximum flexibility and the ability to accommodate the use of any amine package, stainless steel materials of construction have been recommended. It is important to note that in welded applications Type 304L SS is required. The use of "L" grade material will minimize sensitization of the weld HAZ (heat-affected zone) during fabrication, resulting in welds that maintain the required corrosion resistance.

## 4.2 Seawater Cooling Water Service

In seawater the use of the standard 300 Series stainless steels is not viable as these materials are susceptible to severe pitting and crevice corrosion in the marine environment. These materials are also susceptible to chloride stress corrosion cracking when temperature 50 deg C. There are numerous duplex and super-austenitic stainless steel materials that exhibit excellent resistance to pitting and stress corrosion cracking in the marine environment, but these alloys are expensive. It is proposed that Glass Reinforced Plastic (GRP) piping be used in firewater and cooling water service. An epoxy resin based material with an epoxy rich internal chemical resistance barrier should provide adequate resistance for the life of the plant.

Where metallic materials must be used, for example in the seawater cooled plate exchangers, Titanium is recommended. It is resistant to stress corrosion cracking, pitting, and crevice corrosion and will provide superior performance in service.

## 4.3 Other Services

### 4.3.1 Steam, Condensate, and Utility Services

Standard carbon steel materials of construction are suitable for equipment and piping in steam and condensate services. Carbon steel is also suitable plant air, nitrogen, and process water service. Instrument air piping is usually specified to be stainless steel or copper piping. These materials are specified to eliminate the risk of having corrosion product adversely affect the performance of instrumentation.

### 4.3.2 Carbon Dioxide Piping

The recommended material of construction for vessels and piping in carbon dioxide service at the saturation temperature is Type 304L SS. Any subsequent condensation from the saturated vapor will result in the formation of carbonic acid, which is very corrosive toward carbon steel. When the carbon dioxide is above the saturation temperature and has "superheat" carbon steel is a suitable material of construction. This occurs downstream of gas compressors and after the gas has been dried.

### 4.3.3 De-mineralized Water Piping

De-mineralized water that contains dissolved oxygen is very aggressive and corrodes carbon steel. Consequently, Type 304L SS materials are recommended and routinely used in de-mineralized water service.

### 4.3.4 Potable Water

Depending upon water quality carbon steel is suitable for potable water service. However, plastic materials such as PVC and CPVC have been found to be suitable for a wide range of potable water qualities, are relatively simple to install, and provide satisfactory performance. Consequently PVC and CPVC are recommended. Ultra-Violet (UV) resistance grades are required for outdoor exposure.

## 5.0 Protective Coatings

To provide superior corrosion protection and an aesthetically appealing facility, coatings are selected based on their ability to provide sustained corrosion protection for the design life of the plant.

### 5.1 - Surface Preparation

SSPC SP10 was chosen for surface preparation because it is recommended by the paint manufacturer and an industry standard practice for sea coast environments as it increases the long term efficiency, sustainable performance and protection of the coating, yielding a life expectancy of 20 years plus with periodic maintenance as required.

### 5.2 Stainless Steel - Marine Environment Exposure

150-200 μm catalyzed epoxy with an optional polyurethane topcoat is recommended for coating the OD surfaces of stainless steel exposed to the marine environment. The coating will act as a barrier and minimize the risk of chloride stress corrosion cracking and pitting of stainless steel on OD surfaces due to external chloride contamination. Note the use of inorganic zinc silicate or galvanized coatings on stainless steel are prohibited.

### 5.3 Insulated Steel (Carbon Steel and Stainless Steel) Outdoor

Both carbon steel and stainless steel surfaces having a surface temperature less than 121 °C (250 °F) is coated with 150-200 μm of catalyzed epoxy to prevent corrosion (pitting, rust, etc.) under the insulation and to prevent stress corrosion cracking of stainless steel.

### 5.4 Insulated Steel (Carbon Steel and Stainless Steel) Indoor

Manufactures standard is specified for carbon and low-alloy steel equipment and piping to provide sufficient corrosion protection during transport to and storage at the site prior to use. Insulated and un-insulated stainless steel surfaces located indoors are not coated.

### 5.5 Un-insulated Outdoor Exposure

The marine environment is very harsh and causes severe corrosion on un-insulated carbon and low-alloy steel equipment, tanks/vessels, piping, valves, structural and miscellaneous steel exposed to the very humid, chloride-bearing environment. The coating systems described below were selected to maximize corrosion protection of these components. The prime coat shall consist of 75 - 125 µm of ethyl silicate inorganic zinc or rust inhibitive epoxy followed by 100 µm of epoxy top-coated with 75 µm of polyurethane. Note that the external coating requirements for stainless steel exposed to the marine environment were covered separately above.

5.6 Indoor Structural Steel

Selection of inorganic zinc silicate coating is based on its outstanding protective properties, which include its sacrificial corrosion protection properties in combination with its barrier properties and physical characteristics. For indoor exposure this coating will last for the design life of the plant. It is unaffected by weather, sunlight, ultraviolet radiation, rain, dew, bacteria or temperature, and does not chalk. It has a very good chemical resistance to pH level between 5 and 9.

Hot dip galvanized coatings are also suitable for structural elements for indoor service. The minimum and maximum coating weights provided by a typical hot dip galvanizing specification are 320 g/m2 (1 oz/ft2) to 705 g/m2 (2.3 oz/ft2), which translates into a maximum coating thickness of about 100 µm. This coating weight range per m2 is sufficient to provide corrosion protection for the design life of the plant. Hot-dip galvanized coating was chosen for bolts, nuts, gratings, ladders, handrails, etc. because hot dip galvanizing is an economical process for efficiently coating fasteners and small structural components.