


# Corrosion Evaluation for Main Systems

## CO<sub>2</sub> Capture Facility

Kårstø, Norway

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0	21 NOV 08	Issued for Comment	TCK	VCD	<i>BR</i>	<i>AK</i>		
Rev.	Date	Reason for Revision	By	Check	App	App	Client	
 Bechtel Power Corporation			Job No. 25474					
			Document No.				Rev.	
			25474 - 000 - G65 - GEN - 00001				0	
			PAGE 1 of 5					
<b>GASSNOVA</b>			Project No. - Originator - Disc Code - Doc Type - Serial No.					
			10112936 -PB - M - TD0 - 0001					

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## Corrosion Evaluation for Main Systems

### 1.0 PURPOSE

The purpose of this document is to evaluate the corrosivity of the fluids in the main process systems and indicate the materials of construction that are specified for items of equipment and piping in these systems to mitigate against the effects of corrosion. Specific materials of construction requirements and their justifications are also discussed.

### 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 CO<sub>2</sub> contained in the flue gas from the CCPP and deliver liquefied CO<sub>2</sub> 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 specific materials of construction that are used for items of equipment and piping and specifies the required corrosion allowance.

### 4.0 EQUIPMENT ITEMS

#### 4.1 Vessels and Drums

Solid Type 304L SS is required for the pressure-retaining shell and heads for all vessels and drums in amine and saturated CO<sub>2</sub> service. However, depending upon vessel or drum wall thickness the use of carbon steel clad with 1/8 inch of Type 304L SS is allowed. Internals shall also be Type 304 SS ("L" grade if welded). As a corrosion resistant alloy is specified, no general corrosion allowance is required. These requirements apply to the Flue Gas Absorbers (T-101/102), CO<sub>2</sub> Stripper (T-103), Lean Amine Side-Stream Carbon Filter (F-101), Rich Amine Mechanical Filter (F102A/B), Semi-Lean Amine Flash Drum (V-101), Lean Amine Mechanical Filter (F105A/B), Stripper Reflux Drum (V-102), Amine Re-Claimer (X-102), Amine Storage Tank (TK-101), Lean Amine Solvent Storage Tank (TK-102 - Acceptable alternate material would be internally lined carbon steel), CO<sub>2</sub> Compressor Suction Drum (V-103), CO<sub>2</sub> First Stage K.O. Drum (V-104 - As an alternate impact tested carbon steel may be used), and the CO<sub>2</sub> Second Stage K.O. Drum (V-105 - As an alternate impact tested carbon steel may be used). Due to auto refrigeration affects, the CO<sub>2</sub> Surge Drum (V-106) shall be Type 304L SS.

NOTE: The substitution of Type 316 SS, "L" grade for welded applications, in lieu of Type 304/304L SS is acceptable.

#### 4.2 Plate Heat Exchangers

Plate heat exchangers in seawater cooling service shall be fabricated from Titanium. These exchangers are: Wash Water Coolers (E-101 and E-104), Lean Amine Cooler (E-102), and the Overhead Stripper Condenser (E-111). The 300 Series stainless steels may not be used in seawater cooling service. These materials are susceptible to pitting, crevice corrosion, and chloride stress corrosion cracking and are unsuitable for seawater service.

Plate exchangers that are fabricated of Type 304 SS are: Lean/ Rich Amine Exchanger (E-108), Semi-Lean/ Rich Amine Exchanger (E-103), Flash Feed Exchanger (E-107), Flash Feed Heater (E-109), and the Stripper Reboiler (E-110A-D). Note that Type 316 SS may be used in lieu of Type 304 SS.

#### 4.3 Shell and Tube Heat Exchangers

The CO<sub>2</sub> Compressor First, Second, and Third Stage Steam Generators (E-112, E-114, and E-116) have a carbon steel shell on the steam side and stainless steel tubes on the carbon dioxide side.

The CO<sub>2</sub> Compressor First and Second Stage Intercoolers (E-113 and E-115) are in seawater cooling service. Therefore the tube side materials must be resistant to seawater. Acceptable tube materials are titanium, Sea-Cure, or AL6XN. The shell side materials are impact tested carbon steel.

The CO<sub>2</sub> Cooler (E-117) is also in seawater cooling service. Therefore the tube side materials are the same as indicated above for E-113 and E-115. The shell side materials are Type 304L SS.

#### 4.4 Pumps

All amine service pumps shall be constructed of stainless steel materials. Cast material shall conform to grade CF8 or CF8M (CF3 or CF3M if welded and not solution annealed after weld repair) and wrought material shall conform to Type 304 or 316 SS (Type 304L or 316L SS if welded). Applicable pumps are: Rich Amine (P-101A/B and P-124A/B), Wash Water (P-102A/B and P-104A/B), Flash Drum (P-106A/B), Lean Amine (P-105A/B), Reflux (P-107), Fresh Amine Metering (P-110A/B), Lean Amine Solvent (P-111A/B), and the CO<sub>2</sub> Product Send Out Pump (P-108A/B).

For the sea water cooling booster pump (MP-121A/B), the pump shall be constructed of duplex stainless steel ASTM A890, Gr. 1A for cast parts (CD4MCu) and Alloy 2205 or equivalent for the wrought parts.

## 4.5 Piping

### 4.5.1 – Amine Service

Piping in amine service shall be ASTM A312 Type 304L SS. No general corrosion allowance is required. Valves shall have a cast stainless steel body CF8 or CF8M (CF3 or CF3M if not solution annealed after weld repair) and Type 316 SS (Type 316L SS if welded) trim.

### 4.5.2 Non-Amine Service Piping

Steam and condensate piping is to be ASTM A106 Gr. B or ASTM A53 Gr. B with 0.05 inches (1.2 mm) corrosion allowance. Valves shall have a cast steel body, ASTM A216 WCB, with F6 valve trim.

The CO<sub>2</sub> liquid product piping is to be ASTM A312 Type 304L SS due to the potential for auto refrigeration. No general corrosion allowance is required. Valves shall have a cast stainless steel body CF8 or CF8M (CF3 or CF3M if not solution annealed after weld repair) and Type 316 SS (Type 316L SS if welded) trim.

The piping material for the nitrogen service gas, compressed plant air, process water, amine waste and wastewater piping is to be ASTM A106, Gr. B or ASTM A53, Gr. B. Instrument air piping shall be Type 304/304L SS.

The fire water and sea water cooling water piping is to be glass reinforced plastic (GRP).

Potable water piping is to be PVC or CPVC. Use of UV resistant grades will be used for outdoor exposure.

## 5.0 PAINTING/COATING REQUIREMENTS

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
<b>1.0 Structural and Miscellaneous Steel</b>			
1.1 Structural and Miscellaneous Steel including Platform Steel, Pipe and Cable racks - Indoor	SP 10/Sa 2.5	75-125µm of Ethyl silicate Inorganic Zinc	N/A

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
1.2 Structural and Miscellaneous Steel including Platform Steel, Pipe and Cable racks - Outdoor	SP 10/Sa 2.5	75-125µm of Ethyl silicate Inorganic Zinc	100µm of epoxy and 75µm of Polyurethane
1.3 High Strength (A-490) Nuts and Bolts - Indoor	N/A	100µm Epoxy mastic	N/A
1.4 High Strength (A-490) Nuts and Bolts - Indoor	N/A	75µm Epoxy mastic	75µm of epoxy and 75µm of Polyurethane
1.5 Miscellaneous Nuts and Bolts Other Than A-490 - Indoor	N/A	Hot dip galvanized ASTM A 123, or Mechanically galvanized per ASTM B695	N/A
1.6 Miscellaneous Nuts and Bolts Other Than A-490 - Outdoor	N/A	Mechanically galvanized per ASTM B695	75µm of epoxy and 75µm of polyurethane
1.7 Carbon Steel Surfaces Exposed To Splash and Spillage <50°C - Indoor or Outdoor	SP 10/Sa 2.5	150-200µm of high build catalyzed epoxy	150-200µm high build catalyzed epoxy
1.7 Carbon Steel Surfaces Exposed To Water Immersion <60°C	SP 5/Sa 3	250-375µm of high build catalyzed epoxy	250-375µm high build catalyzed epoxy
<b>2.0 Piping and Valves</b>			
2.1 Non-Insulated Carbon Steel Piping and Valves Including Hangers and Supports <400°C - Indoor	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	N/A
2.2 Non-Insulated Carbon Steel Piping and Valves Including Hangers and Supports <104°C - Outdoor	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	75µm of epoxy and 75µm of polyurethane

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
2.3 Non-Insulated Carbon Steel Piping and Valves Including Hangers and Supports >104°C to <400°C - Indoor/Outdoor	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	Two coats, 25-40µm per coat, of high temperature Silicone
2.3 Non-Insulated Stainless Steel Piping and Valves <104°C - Outdoor  (Hangers and Supports Per 2.1)	Sweep Blast (SP 7)	150-200µm of high build catalyzed epoxy	Optional 75µm of polyurethane
2.4 Non-Insulated Stainless Steel Piping and Valves <104°C - Indoor  (Hangers and Supports Per 2.1)	SP10/Sa 2.5	N/A	N/A
2.5 Insulated Stainless Steel Piping and Valves <121°C - Outdoor  (Hangers and Supports Per 2.1)	Sweep Blast (SP 7)	150-200µm of high build catalyzed epoxy	N/A
2.6 Insulated Stainless Steel Piping and Valves <121°C - Indoor (Hangers and Supports Per 2.1)	N/A	N/A	N/A
2.6 Insulated Carbon Steel Piping and Valves To <400°C - Indoor  (Hangers and Supports Per 2.1 or 2.2)	MFR. STD.	MFR. STD.	N/A
2.7 Insulated Carbon Steel Piping and Valves <121°C - Outdoor  (Hangers and Supports Per 2.1 or 2.2)	SP10/Sa 2.5	150-200µm of high build catalyzed epoxy	N/A
2.8 Insulated Carbon Steel Piping and Valves >121°C to	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	N/A

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
<400°C - Outdoor  (Hangers and Supports Per 2.1 or 2.2)			
<b>3.0 Mechanical Equipment</b>			
3.1 Non-Insulated Large (>5 m <sup>2</sup> ) Carbon Steel Mechanical Equipment and Associated Components Including Supports <104°C - Indoor or Outdoor	SP10/Sa 2.5	100-150µm Rust inhibitive catalyzed epoxy primer	75-100 microns of epoxy intermediate and 75-125µm of polyurethane
3.2 Non-Insulated Large (>5 m <sup>2</sup> ) Carbon Steel Mechanical Equipment and Associated Components Including Supports >104°C to <400°C - Indoor or Outdoor	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	Two coats, 25-40µm per coat, of high temperature Silicone
3.3 Non-Insulated Stainless Steel Mechanical Equipment and Associated Components Including Supports <104°C - Outdoor	SP 10/Sa 2.5	150-200µm of high build catalyzed epoxy	Optional 75µm of polyurethane
3.4 Non-Insulated Stainless Steel Mechanical Equipment and Associated Components Including Supports - Indoor	N/A	N/A	N/A
3.5 Non-Insulated Small (<5 m <sup>2</sup> ) Carbon Steel Mechanical Equipment and Associated Components Including Supports to <400°C - Indoor/Outdoor	MFR. STD.	MFR. STD suitable for exposure conditions	MFR. STD suitable for exposure conditions



DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
3.6 Non-Insulated Amine And Other Chemical Skid Steel - Indoor/Outdoor	SP 10/Sa 2.5	250-300µm of chemical resistant coatings	250-300µm of chemical resistant coatings
3.7 Insulated Carbon or Stainless Steel Mechanical Equipment and Associated Components Including Supports to <400°C - Indoor	MFR. STD.	MFR. STD	MFR. STD
3.8 Insulated Carbon or Stainless Steel Mechanical Equipment and Associated Components Including Supports <121°C - Outdoor	SP 10/Sa 2.5	150-200µm of high build catalyzed epoxy	N/A
3.9 Insulated Carbon or Stainless Steel Mechanical Equipment and Associated Components Including Supports >121°C to <400°C - Outdoor	MFR STD	MFR STD	MFR STD
<b>4.0 Tanks or Vessels</b>			
4.1 Non-Insulated Shop Fabricated Carbon Steel Tanks and Vessels <104°C - Outdoor	SP10/Sa 2.5	100-150µm Rust inhibitive catalyzed epoxy primer	75-100 microns of epoxy intermediate and 75-125µm of polyurethane
4.2 Non-Insulated Shop Fabricated Carbon Steel Tanks and Vessels <104°C - Indoor	SP10/Sa 2.5	100-150µm Rust inhibitive catalyzed epoxy primer	75-125µm of polyurethane
4.3 Non-Insulated field erected Carbon Steel Tanks and Vessels <104°C - Outdoor	SP10/Sa 2.5	100-150µm Rust inhibitive catalyzed epoxy primer	75-100 microns of epoxy intermediate and 75-125µm of polyurethane
4.4 Non-Insulated shop fabricated stainless steel Tanks and Vessels <104°C - Outdoor	Sweep Blast (SP 7)	150 - 200µm high build catalyzed epoxy	Optional 75µm of polyurethane
4.5 Non-Insulated shop fabricated stainless steel	N/A	N/A	N/A

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
Tanks and Vessels - Indoor			
4.4 Insulated shop fabricated Carbon Steel Tanks and Vessels <121°C - Indoor	MFR STD	MFR STD	MFR STD
4.5 Insulated shop fabricated Carbon Steel Tanks and Vessels <121°C - Outdoor	SP 10/Sa 2.5	150 - 200µm high build catalyzed epoxy	N/A
4.6 Insulated shop fabricated Stainless steel Tanks and Vessels <121°C - Outdoor	SP 10/Sa 2.5	150 - 200µm high build catalyzed epoxy	N/A
4.7 Insulated shop fabricated Carbon steel Tanks and Vessels >121°C to <400°C - Outdoor	SP10/Sa 2.5	75-125µm of ethyl silicate inorganic zinc	N/A
4.8 Interior of Carbon Steel Tanks and Vessels	Corrosion resistant coating materials or Alloy materials suitable for the design conditions		
<b>5.0 Pumps and Motors</b>			
5.1 Non-Insulated pumps, motors, and supports <104°C - Outdoor	SP10/Sa 2.5	75-100µm rust inhibitive catalyzed epoxy primer	75-100µm of epoxy intermediate and 75-125µm of polyurethane
5.2 Non-Insulated pumps, motors, and supports <400°C - Indoor	MFR. STD.	MFR. STD	MFR. STD
5.3 Insulated pumps <121°C - Indoor or Outdoor	SP10/Sa 2.5	150 - 200µm high build catalyzed epoxy	N/A
<b>5.0 Electrical and Control</b>			
5.1 Switch gears, motor control center, Chargers, Inverters, switchboards, local device, local control panels and cabinets, etc.	MFR. STD.	Manufacturers standard primer and finish or 125-175µm powder coatings suitable for service and environmental conditions	
5.2 Boards/Consoles and other associated	MFR. STD.	Manufacturers standard primer and finish or 125-175µm powder coatings suitable for service and	

DESCRIPTION	SURFACE PREP	PRIMER	FINISH COAT
components		environmental conditions	
5.3 Miscellaneous Electrical and Control instruments	MFR. STD.	Manufacturers standard primer and finish or powder coatings suitable for service and environmental conditions	
5.4 Power Transformers, Enclosure/Modules, and Large (>5 m <sup>2</sup> ) Electrical Equipment	SP10/Sa 2.5	75-100µm rust inhibitive catalyzed epoxy primer	75-100µm of epoxy intermediate and 75-125µm of polyurethane
5.5 Cable trays, cable tray supports, pull boxes, conduit	N/A	Galvanized with plastic coated or powder coating or Optional FRP or PVC (conduits and Pull Boxes)	
5.6 Electrical Motors Indoor or Outdoor	MFR STD	Epoxy primer and epoxy or polyurethane topcoat	
<b>6.0 Misc. Steel</b>			
6.1 Outdoor platform grating, stair grating, toe plates, etc. - Indoor or Outdoor	Per Code	Hot dip galvanized to a minimum of 705 g/m <sup>2</sup> per ASTM A123 or equivalent ISO standard	N/A
6.2 Platform handrail, Stair Steel and ladders - Indoor	SP10/Sa 2.5	Hot dip galvanized to a minimum of 705 g/m <sup>2</sup> per ASTM A123 or equivalent ISO standard	N/A
6.3 Platform handrail, Stair Steel and ladders - Outdoor	SP10/Sa 2.5	Hot dip galvanized to a minimum of 705 g/m <sup>2</sup> per ASTM A123 or 75-100µm rust inhibitive catalyzed epoxy primer	75-100µm of epoxy intermediate and 75-125µm of polyurethane
6.3 Grating for Chemical trench and Sump (Non-vehicular Traffic)		FRP	