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Heavy Oil

Controlled Document

Quest CCS Project

Corrosion Management Framework

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Summary

Scotford Upgrader Quest Carbon Capture & Sequestering Project Integrated Corrosion Control Manual.

Keywords

SHELL CANADA LIMITED

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INTEGRATED CORROSION CONTROL MANUALs

QUEST CARBON CAPTURE & SEQUESTERING PROJECT

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REVISION INDEX

Date	Rev	Description	Pages Revised
23-Oct-14	0	Approved (by Harm de Groot)	

1.0 INTRODUCTION

1.1 Purpose of this Manual

118.52.01-IPIS program

1.2 Purpose of the Unit

The Quest Carbon Capture and Sequestering (CCS) Project is designed to capture, compress and store about 1.08 million tonnes of CO_2 per year from the Shell Canada Scotford Upgrader.

The project consists of four distinct units: amine treating, CO2 compression and dehydration, CO_2 transport by pipeline, and CO_2 storage.

1.3 PROCESS DESCRIPTION

1.3.1 Amine Treating Unit

The main purpose of the CCS Amine Unit is to extract acid gases, in this case dominantly CO_2, from gaseous hydrocarbon streams inside of Absorbers (absorption reaction) into the amine solvent. The CCS Amine System uses a licensed ADIP-X Process. Besides the CO_2, the amine solution can absorb or react with different efficiency with other gases or compounds such as Cyanides, Chlorides, organic acids, ammonia and others.

The Amine Unit process is subdivided into five (5) sections. Their descriptions follow

1.3.1.1 Absorption Section

Amine Absorber #1 and Amine Absorber #2 are each designed to treat gas from HMU-1 and HMU-2, respectively. Feed composition, process conditions and flows are the same and therefore have identical design. Amine Absorber #3 treats gas from HMU-3.

Each absorber is provided with a feed gas bypass to accommodate turnaround or any upset situations in the CO_2 capture unit. This arrangement allows a portion or 100% of the rich hydrogen gas to bypass an absorber and be mixed with the treated gas to either bring the combined gas CO_2 content to a desired level or be sent directly to downstream PSA unit. The bypass arrangement is a better control scheme than manipulating amine circulation or lean amine loading.

To minimize gas entrainment in the rich amine to 1.0 vol % of amine circulation and to reduce hydrogen loss, a collector tray with downpipes is added below the bottom tray (tray1) of each absorber along with a 600 mm bed of #2 Raschig Rings in the bottom heads. To minimize amine entrainment with the treated gas stream leaving the top of the absorbers, demisters are installed at the gas outlets.

1.3.1.2 Water Wash Section

Each water wash section consists of a water wash vessel, circulating water cooler and circulating water wash pumps. The water wash vessel have two sections, the bottom section is a re-circulating section with 6 valve trays and the top section is a polishing section with 3 bubble cap trays. The top portion of the vessels above the polishing section includes de-entrainment devices.

1.3.1.3 Amine Regeneration Section

The combined rich amine from all three absorbers is treated in the regeneration section where CO_2 is stripped from the solution. The regeneration section consists of a reboiled amine stripper, an overhead condenser and a reflux drum. Rich amine is removed from the absorber bottoms on level control and collected in a common line.

In the bottom stripping section of the amine stripper, the CO_2 in the amine is removed by stripping steam. $CO_2$is removed from the amine solution by a combination of high temperature, low pressure, and stripping steam (to reduce the acid gas partial pressure). The contact between the stripping steam and solvent is performed within the regenerator using trays. Steam generated by re-boiling the solvent provides:

i. Heat for raising the temperature of the feed (rich amine)
ii. Heat of de-sorption of CO_2
iii. Heat to generate stripping steam (to reduce CO_2 partial pressure).

To prevent amine degradation, the temperature of the unheated surface on the amine side should be below 140°C.

1.3.1.4 Cooling and Filtering Section

The hot lean amine from the Amine Stripper V-24601 is pumped out by Lean Amine Booster Pumps P-24601 A/B/C through the Lean / Rich Amine Exchanger E-24602 A/B plate exchangers where the lean amine is cooled to [redacted] °C. The lean amine is then further cooled to [redacted] °C in the shell side of the Lean Amine Coolers E-24604 A/B. These coolers use cooling water on the tube side. Lean Amine Trim Coolers E-24605 A/B plate exchangers cool the lean amine to 30°C using cooling water.

The cooled lean amine is treated in the filtration section before it is returned to the Amine Absorbers V-24119, V-24219 and V-44119. The filtration section consists of the Lean Amine Filter V-24604 followed by a slipstream through the Lean Amine Carbon Filter V-24608 and the Lean Amine Post Filter V-24609. The main particulate filter is sized for 25% of the lean amine flow whereas the carbon filter is sized for approximately 5% of the lean amine flow.

The filtered lean amine is returned to the V-24119, V-24219 and V-44119 by the Lean Amine Charge Pump P-24602 A/B/C.

Make-up lean amine is stored in Amine Make-Up Tanks TK-24601 and TK-24602. The tank is equipped with an inert gas purge to guard against amine degradation. A low pressure stream coil provides a heat source. Lean amine is added upstream of E-24604 A/B using Amine Make-Up Pump P-24605.

Amine Drain Drum V-24606 collects liquids removed by the Compressor Suction KO Drum V-24701. The drum is equipped with an inert gas purge to guard against amine degradation.

1.3.1.5 Waste Streams

During operation, there are four “waste” stream generated in the Amine Unit. These are:

- Water purge from the amine overhead reflux section to the Waste Water System. Normally, there will be no flow in this stream as water addition is expected to maintain the system water balance.

- Water purge from Absorber #1 water wash vessel (V-1) and Absorber #2 water wash vessel (V-2). A portion of these streams is used as water make-up for amine unit and the remaining goes to the existing waste water treatment facility.
- Water purge from Absorber #3 water wash vessel (V-3). This stream is sent to the existing waste water treatment facility.

1.3.1.6 Utility Streams

Several utility streams are employed in the unit. They include:

- Low pressure steam is used for Stripper Reboilers and Amine Make-Up Tank heating coil.
- Low pressure condensate is cooled through the LP Condensate/Demin Water Exchanger before entering the Condensate Flash Drum
- High pressure condensate from the TEG Stripper Heater Condensate is also collected in the Condensate Flash Drum. The recovered condensate is streamed through the Recovered Clean Condensate Pumps, Condensate Cooler and Water make-Up Pumps returning to the Absorber Wash Water Vessels.
- Condensate is cooled in Water Make-up and streamed through from the Water Make-up Booster Pumps
- Demineralized water from the Deaerator Feed System recovers heat through the LP Condensate/Demin Water and is returned to the Deaerator.

1.3.1.7 Feed Sources

The hydrogen feed gas from HMU 1, HMU 2 and HMU 3 operating conditions and gas flow rates are summarized below.

Feed Gas Definition		HMU 1 (241) to V-24118	HMU 2 (242) to V-24218	HMU 3 (441) to V-44118
Temperature	^oC	[redacted]	[redacted]	[redacted]
Pressure	Bar (a)	30.57	30.57	30.97
Flow	Kg-mol/h	7106.4	7106.4	10342.8

1.3.2 CO2 Compression & Dehydration

The recovered CO_2 is compressed in an eight stage integrally geared centrifugal compressor with an electric motor drive. In the first 5 stages, free water is separated out through compression and cooling. The $_{CO2}$ from the 6th stage of compression is processed through a TEG dehydration unit to reduce the water content to a maximum of 6 lb per MMSCF. In the final two stages, the CO_2 stream is compressed to an operating discharge pressure in the range of 8, 000-11,000 kPag resulting in a dense phase fluid (supercritical). The CO_2 Compressor is able to provide a discharge pressure as high as 14,790 kPag at a reduced flow for start-up and other operating scenarios. This dense phase CO_2 is transported by pipeline from the Scotford Upgrader to the injection locations which are located up to approximately 64 kilometres from the Upgrader.

1.3.2.1 Process Feed

The design of the CO_2 Compressor is based on compressing the CO_2 recovered from the CO_2 Capture and Amine Regeneration sections from 38 kPag to 14,790 kPag. The discharge pressure is set in accordance with the pipeline and well requirements at initial start-up and for future operation, and is at the functional operating limits of the 900# carbon steel pipeline (at 60°C). During normal operation, after the wells are conditioned, the operating pressure will be reduced to 12,000 kPag, to reduce power consumption.

The design of the Dehydration Unit is to reduce the presence of water in the CO_2 to 6 lb / MMSCF using TEG. The water-rich TEG is regenerated using a combination of reboiler with low temperature high pressure steam as the heating medium and nitrogen stripping to restore the TEG concentration to above 99 wt%. The dehydration unit is installed after the 6th stage of compression to take advantage of the natural water saturation properties of CO_2 at 5000 kPaa. Table 7.1 demonstrates feed to the compressors.

1.3.2.2 Compression

The CO_2 from Amine Regeneration is routed to the compressor suction, via the Compressor Suction KO Drum to remove any free water. The CO_2 Compressor is an eight stage integrally geared centrifugal machine. Increase in H_2 impurity from 0.67% to 5% in CO_2 stream requires the minimum discharge pressure to keep CO_2 in supercritical condition to about 8500 kPag. H_2 impurity >5% may, lead to potential surge situations.

Cooling and separation facilities are provided on the discharge of the first five compressor stages. The condensed water streams from the interstage KO drums are routed back to the Stripper Reflux Drum to be degassed and recycled as make up water to the amine system. The condensed water from the Compressor 5th and 6th Stage KO Drums and the TEG Inlet Scrubber are routed to the Compressor 4th stage KO Drum. This routing reduces the potential of a high pressure vapor breakthrough on the Stripper Reflux Drum and minimizes the resulting pressure drops. The 7th Stage KO Drum liquids are routed to the TEG Flash Drum due to the likely presence of TEG in the stream.

The saturated water content of CO_2 at 36°C approaches a minimum at approximately 5000 kPaa. Consequently, an interstage pressure in the 5000 kPaa range is specified for the compressor. This pressure is expected to be obtained at the compressor 6th Stage Discharge. At this pressure, the wet CO_2 is air cooled to 36°C and dehydrated by triethylene glycol (TEG) in a packed bed contactor.

The dehydrated CO_2 is compressed to a discharge pressure in the range of 8, 000-11,000 kPag resulting in a dense phase fluid (supercritical). The $_{CO2}$ Compressor is able to provide a discharge pressure as high as 14,790 kPa at a reduced flow for start-up and other operating scenarios. The supercritical CO_2 is cooled in the Compressor Aftercooler to 43°C, and routed to the CO_2 Pipeline. This dense phase CO_2 is transported by pipeline from the Scotford Upgrader to the injection locations which are located up to approximately 64 kilometres from the Upgrader.

1.3.2.3 Dehydration

A lean triethylene glycol (TEG) stream at a concentration greater than 99 wt% TEG contacts the wet CO_2 stream in an absorption column to absorb water from the CO_2 stream. The water rich TEG from the contactor is heated and letdown to a flash drum which operates at approximately 270 kPag. This pressure allows the flashed portion of dissolved CO_2 from the rich TEG to be recycled to the Compressor Suction KO Drum.

The flashed TEG is further preheated and the water is stripped in the TEG Stripper. The column employs a combination of reboiling, via a stab-in reboiler using low temperature HP Steam, and nitrogen stripping gas to purify the TEG stream. Nitrogen stripping gas is required to achieve the TEG purity required for the desired CO_2 dehydration, as the maximum TEG temperature is limited to 204°C to prevent TEG decomposition. Stripped water, nitrogen and degassed CO_2 are vented to atmosphere at a safe location above the TEG Stripper.

Though, the system is designed to minimize TEG carryover, it is estimated that 27 PPMW of TEG will escape with CO_2. The dehydrated CO_2 is analysed for moisture and composition at the outlet of TEG unit.

The lean TEG is cooled in a Lean / Rich TEG Exchanger. The lean TEG is then pumped and further cooled to 39 °C in the Lean TEG Cooler with cooling water and returned to the TEG Absorber.

1.3.2.4 Key Operating Parameters

The following are key operating parameters for the CO2 Compression and Dehydration Units.

<u>CO_2 Compression</u>

Compressor Discharge Pressure:	8,000 - 11,000 kPag (Note 1) Note 1: The CO2 Compressor is able to provide a discharge pressure as high as 14,790 kPa at a reduced flow for start-up and other operating scenarios.
Cooler Outlet Temperatures:	42°C (water cooled services) 36°C (air cooled services)
Pipeline CO_2 Temperature:	43°C

<u>CO_2 Dehydration</u>

Product CO_2 H_2O Content	6 lb / MMSCF (Note 2) Note 2: Water content specification is a maximum of 6 lb per MMSCF during the summer months and a maximum of 4 lb per MMSCF during the required

	periods of the remaining seasons with ambient temperatures up to approximately 20°C.
CO_2 Inlet Pressure	3800 to 5200 kPag
Lean TEG Loading	>99 wt% TEG

1.3.3 CO2 Transport Pipeline

The purpose of the Quest CCS Pipeline is to transport the recovered, compressed and dehydrated dense phase CO_2 from the Scotford Upgrader to the injection locations which are located up to approximately 64 kilometres away from the Upgrader.

1.3.3.1 Process Feed

The dense CO_2 enters the pipeline with a pressure (minimum and maximum of 7.4 and 14 MPa, respectively) and high CO_2 purity (99.23% CO_2 minimum) to keep it in the supercritical state. Water contents will be maintained at below 6 lb per MMSCF at all times.

1.3.3.2 Process Description

The dense phase CO_2 transportation is designed at the functional operating limits of a 900class carbon steel pipeline. During normal operation, after the wells are conditioned, the operating pressure will be reduced to 12,000 kPag, to reduce power consumption.

1.3.3.3 Key Operating Parameters

The following are key operating parameters for the CO2 Pipeline.

<u>CO_2 Pipeline</u>

Design Pressure:	14,790 kPag
Operating Pressure	12,000 kPa
Design Temperatures:	60°C
Operating Temperature:	36°C

<u>CO_2 Dehydration</u>

Product CO_2 H_2O Content	Summer: 4 lb / MMSCF // winter: 6 lb / MMSCF

1.3.4 CO2 Injection & Sequestration Unit

The main purpose of the CO_2 downhole storage is to inject dense CO_2, from the pipeline to the storage wells located about 52 to 64 km from the Upgrader.

1.3.4.1 Process Description

CO_2 is injected downhole as a dense \tubing to a reservoir about 2000 m below. In the injection reservoir CO_2 will be maintained as a dense phase as long as the fluids are injected at the pressure necessary to maintain a dense CO_2 phase.

There is a provision when the dense CO_2 is not injected for a prolonged period the well will be temporarily plugged to prevent water vapor movement and condensing

To prevent CO_2 migration upward in the casing annulus, the packer has been selected to minimize CO_2 diffusion. To minimize pressure differential across the packer, which might allow CO_2 diffusion, an oil column is maintained in the casing annulus. To further minimizing pressure fluctuation across the packer, the pressure of vapor space (gas cap) above the oil column is regulated by a high pressure high quality nitrogen source. A proprietary XLSX computer program has been developed to maintain proper pressure inside the casing annulus to minimize pressure across the packer and to minimize corrosion in the casing annulus as well.

1.3.4.2 Feed Sources

The dense CO_2 gas arriving at the disposal wells undergoes a pressure drop and has the following property:

COMPONENTS	UNIT	MINIMUM	MAXIMUM
CO2	MOL %	99.23%	
TEMPERATURE	^{O}C	25	45
PRESSURE	KPA	7000	14,500

The dense CO_2 is injected downhole thru carbon steel tubing. As the dense phase contains no free water, corrosion should be zero. When this dense CO_2 enters the formation through the perforated casing, it mixes with the formation water and can become corrosive.

The oil column inside the casing annulus has the following properties:

COMPONENTS	UNIT	MINIMUM	MAXIMUM
OIL TYPE	LOW-WATER DIESEL		
CO2	MOL %	ZERO	ZERO AS SUPPLIED
WATER	G PER M3 OF OIL	ZERO	100 PPM

TEMPERATURE	^{O}C	25	45
HEIGHT	M	2030 M	2030 M
OIL DENSITY	KG/L AT 25C	0.8	0.85
STATIC PRESSURE BY THE OIL COLUMN	KPA	16,000	16,000

The gas cap above the oil column has the following properties

COMPONENTS	UNIT	MINIMUM	MAXIMUM
NITROGEN	PURITY	99% PURITY	99.5% PURITY
CO2	MOL %	ZERO	ZERO AS SUPPLIED
WATER	G PER M3 OF NITROGEN	ZERO	10 PPM
TEMPERATURE	^{O}C	25	45
NITROGEN VOLUME	M3	40	130
PRESSURE OF THE GAS CAP	MPA	8	10

2.0 DAMAGE MECHANISMS

2.1 Introduction

The following damage mechanisms are discussed in section 3 in the corrosion circuits. The following is intended to be a summary description of each mechanism. The description is taken from the Visions Database for continuity. If more information is required, it is recommended that you visit the Shell AMMI wiki site for more descriptive information.

2.2 Descriptions

2.2.1 CO_2 Corrosion

Results when CO2 dissolves in water to form carbonic acid (H2CO3). The acid may lower the pH and sufficient amount may promote general, localized corrosion and/or pitting corrosion of carbon steel and low alloy steels. Factors affecting CO2 include pressure, temperature and CO_2 partial pressure.

2.2.2 Brittle Fracture

Brittle fracture is a rapid fracture that occurs with little or no plastic deformation. Generally, construction materials are ductile and undergo large deformation and/or some form of stable crack growth prior to failure.

2.2.3 Chloride Stress Corrosion Cracking

Chloride Stress Corrosion Cracking (Cl-SCC) is a stress corrosion cracking mechanism that can occur in austenitic stainless steels and certain other austenitic alloys exposed to aqueous, chloride-containing environments above approximately 60^{o}c.

2.2.4 Cooling Water

Cooling water corrosion is one of the major causes of leaks in refineries, gas plants and chemical plants. Cooling water leaks can cause significant Health, Safety, and Environmental impact as well as significant production losses.

2.2.5 Corrosion Fatigue

Corrosion fatigue is a form of fatigue in which cracking of the material occurs in the combined presence of a corrosive environment and cyclic loading. The effect of the corrosive environment is to cause the material to fail faster than it normally would.

2.2.6 Crevice Corrosion

It is a localized corrosion in crevices or shielded regions due to the presence of stagnant water with high concentration of corrosive species (CO2, H2S, Cl-, O2). Factors influencing the crevice corrosion are crevice geometry

2.2.7 Under Deposit Corrosion

Severe localized attack of carbon steel and stainless steel is often noticed under deposits and/or in crevices; whereas the adjacent areas are not corroded at all. The main cause is the presence of sufficient chlorides and a corrodent-like oxygen.

2.2.8 Corrosion under Insulation (CUI)

Corrosion under insulation (CUI) occurs when water enters external insulation through holes or gaps in the insulation covering, or when moisture in the air condenses on the metal surface below the insulation (known as sweating).

2.2.9 Erosion

Erosion/corrosion when a fresh steel surface starts to corrode, the positive iron ions may form components of very low solubility (e.g., hydroxyls and sulfides). If their concentration is sufficiently high, they may deposit immediately on the surface.

2.2.10 Erosion/ Corrosion

Erosion Corrosion is the corrosion of the metal surface due to the removal of protective or fragile scale from the metal surface and exposing the fresh metal surface directly in contact with corrosive fluid. The corrosion is usually localised at bends and elbows or chokes.

2.2.11 External Corrosion

External corrosion is a general corrosion under the conditions of soil, soil to air interfaces, water, water to air interfaces or splash zones, and under insulation and fireproofing. Prevention/ Mitigation: Applying barrier coating or galvanized coating.

2.2.12 Galvanic Corrosion

Galvanic corrosion is the localized corrosion due to coupling of dissimilar metals in presence of corrosive electrolyte. Corrosion occurs where an active metal or surface is electrically coupled with a more passive metal or surface.

2.2.13 Lean Amine Corrosion

Aqueous solutions containing alkanolamines are commonly used in treating processes to remove acid gases, primarily H_2S and CO_2, from various gas or liquid hydrocarbon streams. The most commonly used amine solutions are 20 wt% monoethanolamine (MEA), 30-35 wt% diethanolamine (DEA), 40-50 wt% methyldiethanolamine (MDEA), 35 wt% diisopropanolamine (DIPA), and 35-50 wt% diglycolamine (DGA). Other proprietary acid gas treating processes utilise amine solutions whose formulation may include physical solvents (e.g., Sulfolane) or solution additives

In lean circulating amine solutions contain impurities (or contaminants) such as organic acid anions (formate, acetate, etc., commonly known as heat stable salts), elemental sulphur/polysulphides, suspended solids, and amine polymers. Build-up of impurities reduces the available amine content, which can lead to higher acid loadings and higher corrosion rates. Some of these impurities also have the ability to form metal complexes that enhance corrosion by reducing the protectiveness of the film, especially at elevated temperatures. As a result, corrosion often occurs in the hot areas of the lean amine system such as the lower section of the regenerator, reboilers, the hotter lean/rich exchangers, and associated piping.

Process stream velocity will influence the amine corrosion rate and nature of attack. Corrosion is generally uniform however high velocities and turbulence will cause localized thickness losses. For carbon steel, common velocity limits are generally limited to 3 to 6 fps for rich amine and about 2 fps for lean amine

Rich Amine Corrosion

Aqueous solutions containing alkanolamines are commonly used in treating processes to remove acid gases, primarily H_2S and CO_2, from various gas or liquid hydrocarbon streams. The most commonly used amine solutions are 20 wt% monoethanolamine (MEA), 30-35 wt% diethanolamine (DEA), 40-50 wt% methyldiethanolamine (MDEA), 35 wt% diisopropanolamine (DIPA), and 35-50 wt% diglycolamine (DGA). Other proprietary acid gas treating processes utilise amine solutions whose formulation may include physical solvents (e.g., Sulfolane) or solution additives.

Pure (fresh) amine solutions are non-corrosive. The alkalinity of the amine solution (typically at a pH of 10.5-11.0) produces a passive iron oxide film on carbon steel. The amine solution becomes more corrosive as it absorbs H_2S and/or CO_2. The primary variables affecting corrosion are the acid gas content of the solution (e.g., "acid gas loading"), impurities, fluid velocity, and temperature.

In Rich Amine Solutions as the acid gas loading increases, the amine solution pH drops from the 10.5 - 11.0 range to the 8.5 - 9.5 range, depending upon the amine type. For carbon steel in CO_2-containing solvents, the corrosion reaction is partly inhibited by the formation of a relatively friable iron-carbonate film. By contrast, the iron-sulphide scale, formed in the presence of H_2S, is protective, and corrosion rates are much lower. Even small quantities of H_2S reduce the rate of CO_2 corrosion of carbon steel by enhancing the protective nature of the iron carbonate/sulphide scale present on the steel surface. Units handling feed with a H_2S fraction higher than 5% (volume) of the total acid gas (H_2S + CO_2) have been reported to experience less corrosion.

Process stream velocity will influence the amine corrosion rate and nature of attack. Corrosion is generally uniform however high velocities and turbulence will cause localized thickness losses. For carbon steel, common velocity limits are generally limited to 3 to 6 fps for rich amine

2.2.15 Oxygen Corrosion

Presence of oxygen in the aqueous environment could cause localized pitting of carbon steel. The difference in oxygen concentration from one area to other, within a system, could accelerate corrosion in areas with lower oxygen concentration.

2.2.16 Overpressure

Overpressure in a piping or pipeline can be either due to presence of Hydrates, increase in flow rate/ pressure above design flow rate/ pressure or solid build-up. This can lead to pipe burst and cracking. Prevention/ Mitigation:

2.2.17 ROW Damage

This applies to Pipelines only. Damage to the pipeline may occur due to 3rd party construction activity or unauthorized activity. Prevention/ Mitigation: Regular ROW inspection to monitor 3rd party activities.

2.2.18 Steam Condensate

Condensate System Corrosion in condensate systems is typically due to acidity arising from carryover of acid gases in the boiler steam. The most recognized of these is CO2 resulting from decomposition of residual hardness in the boiler.

3.0 CORROSION CIRCUITS

3.1 CC24101, CC24201, CC44101 – feed gas to Absorbers

3.1.1 Circuit Description

Feed gas to the inlet of the Amine Absorber V-24118, V-24218 and V-44118 and the bypass lines to the HV-241015, HV-242015 and HV-441015 upstream of the intersection with the H_2 Raw Gas to the PSA units.

3.1.2 Equipment and Materials

CC24101, CC24201, CC44101	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	2964	304/304L SS dual certified
Equipment				
None				

3.1.3 Reasons for Materials of Construction

The complete circuit is manufactured of 304/304L SS dual certified in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

No CO_2 corrosion is expected under normal operating conditions.

3.1.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

No active corrosion mechanisms expected

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.1.5 Inspection History – Highlights

3.1.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.1.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.1.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.1.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.1.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

3.1.11 Recommendations and Material Changes

None

3.2 CC24102, CC24202, CC44102 – treated gas before Water Washing

3.2.1 Circuit Description

From the feed gas inlet, treated gas through the Amine Absorbers V-24118, V-24218 and V-44118 to the inlet of the Absorber Water Wash Vessels V-24119, V-24219 and V-44119.

The Circuit includes the Amine Absorbers above the half-pipe inlet distributors.

3.2.2 Equipment and Materials

CC24102, CC24202, CC44102	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	2921	304/304L SS dual certified
Equipment				
V-24118	Amine Absorber # 1			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-24218	Amine Absorber # 2			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-44118	Amine Absorber # 3			CS + 3mm 304L SS Clad, Internals 316 or 316L SS

3.2.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

No CO_2 corrosion is expected under normal operating conditions.

The vessels are SS clad due to the potential for CO_2 and/or amine corrosion.

3.2.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

No active corrosion mechanisms expected

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.2.5 Inspection History – Highlights

3.2.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.2.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	Antifoam Injection	Underdeposit corrosion

3.2.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.2.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions

3.2.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

3.2.11 Recommendations and Material Changes

None

3.3 CC24103, CC24203, CC24301, CC44103 – treated gas after Water Washing

3.3.1 Circuit Description

From the gas inlet, treated gas through the Absorber Water Wash Vessels V-24119, V-24219 and V-44119 to the junctions with the lines upstream of the Dow Hydrogen Rich Gas to the PSA S-24301, S-24401 and S-44301. The Circuit includes the Absorber Water Wash Vessels.

3.3.2 Equipment and Materials

CC24103, CC24203, CC24301, CC44103	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
V-24119 to S-24301	Main piping to PSA and piping to Flare PV-241067 and raw gas bypass downstream of HV-241015	[redacted]	2894	304/304L SS dual certified
V-24219 to S-24404	Main piping to PSA and piping to Flare PV-242067 and raw gas bypass downstream of HV-242015	[redacted]	2894	304/304L SS dual certified
V-44119 to S-44301	Main piping to PSA and piping to Flare PV-441067 and raw gas bypass downstream of HV-441015	[redacted]	2934	304/304L SS dual certified
Equipment				
V-24119	Absorber 1 Water Wash Vessel			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-24219	Amine Absorber 2 Water Wash Vessel			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-44119	Amine Absorber 3 Water Wash Vessel			CS + 3mm 304L SS Clad, Internals 316 or 316L SS

3.3.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

No CO_2 corrosion is expected under normal operating conditions.

The treated gas is water washed to reduce any amine carry over to the PSA units to less than 1 ppmw as well as to cool down the CO_2 gas The vessels are SS clad due to the potential for CO_2 and/or amine corrosion.

3.3.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.3.5 Inspection History – Highlights

3.3.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.3.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.3.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.3.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions

3.3.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

3.3.11 Recommendations and Material Changes

None

3.4 CC24104, CC24204, CC24614, CC44104, – Wash Water

3.4.1 Circuit Description

The wash water is madeup from the V-24607 Condensate Flash Drum through the P-24608A/B Pumps and the E-24607 Condensate cooloer and P-24609A/B pumps

Water from the bottom of the Absorber Water Wash Vessels V-24119, V-24219 and V-44119 through the Circulating Wash Water Pumps P-24108 A/B, P-24208 A/B and P-44108 A/B and the shell sides of the Absorber Circulating Water Coolers E-24129, E-24229 and E-44129 returning to the Absorber Water Wash Vessels.

Water from the bottom of the Absorber Water Wash Vessels V-24119 and V-24219 to junction with the line from the Stripper Overhead Condenser E-24601 A/B to the Amine Stripper V-24601.

Water from the bottom of the Absorber Water Wash Vessel V-44119 to the junction with the line from Process Consensate Seperator V-44106 to the Process Steam Blowdown Drum V-41111

3.4.2 Equipment and Materials

CC24104, CC24204, CC44104	**Description**	**Normal Operating Conditions**		**Material**
		T (°C)	**P (kPag)**	
Piping				
General Piping	Piping to flow control valves	[redacted]		CS + 1.5mm
General piping	Piping downstream of flow control valves	[redacted]	2920 to 3150	304/304L SS dual certified
Equipment				
E-24129	Absorber 1 Circulating Water Cooler			CS + 3mm 304L SS Clad shell, tube and tube sheet super duplex UNS S32750
E-24229	Absorber 2 Circulating Water Cooler			CS + 3mm 304L SS Clad shell, tube and tube sheet super duplex UNS S32750
E-44129	Absorber 3 Circulating Water Cooler			CS + 3mm 304L SS Clad shell, tube and tube sheet super duplex UNS S32750
P-24108 A/B	Absorber 1 Circulating Wash Water Pumps			Casing and Impeller are 316 SS

CC24104, CC24204,	**Description**	**Normal Operating Conditions**		**Material**
P-24208 A/B	Absorber 2 Circulating Wash Water Pumps			Casing and Impeller are 316 SS
P-44108 A/B	Absorber 3 Circulating Wash Water Pumps			Casing and Impeller are 316 SS
E-24607	Condensate Cooler			SH: CS + 3mm CA
V-24607	Condensate Flash Drum			CS + 3mm CA
P-24608 A/B	Recovered Clean Condensate Pumps			Casing and Impeller are CS
P-24609 A/B	Water Make-Up Pumps			Casing and Impeller are CS

3.4.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

The circulating wash water has traces of CO_2 and amine.

No CO_2 corrosion is expected under normal operating conditions.

3.4.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.4.5 Inspection History – Highlights

3.4.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.4.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.4.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.4.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.4.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

3.4.11 Recommendations and Material Changes

None

3.5 CC24105, CC24205, CC44105 – rich amine

3.5.1 Circuit Description

Rich amine from the bottom of the Amine Absorbers V-24118, V-24218 and V-44118 to the inlet of the Lean / Rich Amine Exchanger E-24602 A/B plate exchangers. Circuit includes pipe rack 285 and 485 piping.

The Circuit includes the section of the Amine Absorbers below the the half-pipe inlet distributors.

3.5.2 Equipment and Materials

CC24105, CC24205, CC44105	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	2964 to 3004	304/304L SS dual certified
Equipment				
V-24118	Amine Absorber # 1			CS + 3mm 347 SS Clad, Internals 316 or 316L SS
V-24218	Amine Absorber # 2			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-44118	Amine Absorber # 3			CS + 3mm 347 SS Clad, Internals 316 or 316L SS

3.5.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

The acid gas loading and quality of the rich amine will determine corrosivity. Under normal operating conditions, no corrosion is anticipated in the stainless steel piping and cladding. .

3.5.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

AREAS AFFECTED	DEGRADATION	NOTES

3.5.5 Inspection History – Highlights

3.5.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.5.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.5.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.5.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions

3.5.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.5.11 Recommendations and Material Changes

None

3.6 CC24601 –hot rich amine

3.6.1 Circuit Description

Rich amine from the inlet of the Lean / Rich Amine Exchanger E-24602 A/B plate exchangers to the inlet of the Amine Stripper V-24601.

The Circuit includes the portion of the Amine Stripper from tray #1 to the schoepentoeter inlet distributors.

3.6.2 Equipment and Materials

CC24601	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	2659	304/304L SS dual certified
Equipment				
E-24602 A/B	Lean / Rich Amine Exchanger			CS Frame, 316/316L SS dual certified plates, EPDM gaskets
V-24601	Amine Stripper			CS + 3mm 304L SS Clad, Internals 316 or 316L SS, 347SS clad restoration

3.6.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration. Downstream of the control valve PV010-AB has 1.5mm corrosion allowance. The plate exchangers are 316/316L SS dual certified. This material was selected due to the Rich Amine environment with CO_2.

The acid gas loading and quality of therich amine will determine corrosivity. Under normal operating conditions, no corrosion is anticipated in the stainless steel piping or Stripper.

If solids have not been adequately removed by filtration, CO_2 gas breakout might begin in the piping downstream of the Lean/Rich Exchanger E-24602 A/B. Two-phase flow results in increased liquid velocity and also potential cavitations due repeated bubble formation/ collapse.

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3.6.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Piping elbow, bends, etc. where fluid velocity is high	Vibration & Corrosion Fatigue	
Piping elbow, bends, etc. where fluid velocity is high	Erosion due to impingement by solids and/or gas breakout	Erosion corrosion can happen even when the liquid velocity was calculated to be within the limit for single phase flow. corrosion most likely to occur downstream of control valves Predictibility: FAIR

3.6.5 Inspection History – Highlights

3.6.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
E-24602 A/B	Cl SCC/ Gasket Degradation	The exchangers are specially designed units and require special attention during assembly. The elastomers used for the SS plates must be certified free of Cl or any other halide or leachable sulphide, which could cause stress cracking of the plate material. Materials recommended for the use is EPDM. Verify the gasket specification from “as shipped” documentation for this ‘freedom from halide certification’. Cracking problems have been experienced mostly on rich side.

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
Erosion	downstream of control valves and control valves	Check with UT/RT

3.6.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
TBD	Anti-Foam injection into rich amine stream to V-24601	Localized / Quill Vibration

3.6.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.6.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
Rich amine outlet from E-24602 A/B	[redacted] °C	Temperature	Higher Temperature increases gas breakout tendency
Rich acid gas loading	TBD	Loading	Actual acid gas loading can be much higher than calculated value, resulting in more severe corrosion.

3.6. 10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.6.11 Recommendations and Material Changes

None

3.7 CC24602 – hot lean amine

3.7.1 Circuit Description

Hot lean amine from the bottom of the Amine Stripper V-24601 through the Lean Amine Pumps P-24601 A/B/C to the outlet of the Lean / Rich Amine Exchangers E-24602 A/B plate exchangers.

Hot lean amine from the draw tray of the Amine Stripper V-24601 to the shell sides of the Stripper Reboilers E-24603 A/B. Hot lean vapors and hot lean liquid returning to V-24601.

The Circuit includes the section of V-24601 below tray #1. Circuit also includes piping in units 241, 424, 441.

3.7.2 Equipment and Materials

CC24602	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	81 to-1216	304/304L SS dual certified
Equipment				
E-24602 A/B	Lean / Rich Amine Exchanger			CS Frame with 316L liner, 316/316L SS dual certified plates, EPDM gaskets
E-24603 A/B	Stripper Reboilers			SH: CS + 3mm 304L SS Clad TS: 304L SS Tubes: 316/316L CC dual certified
V-24601	Amine Stripper			CS + 3mm 304L SS Clad, Internals 316 or 316L SS, 347SS clad restoration
P-24601 A/B/C	Lean Amine Pumps			Casing and Impeller are 316 SS

3.7.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration. The plate exchangers are 316/316L SS dual certified. The Stripper reboiler shell is carbon steel with 304L cladding. The tubesheet is 304L SS, the tubes are 316/316L SS. This material was selected due to the Lean Amine environment with CO_2.

The acid gas loading and quality of the lean amine will determine corrosivity. Under normal operating conditions, some corrosion is anticipated in the stainless steel piping and Stripper reboiler tubes.

While CO_2 partial pressure is low, the high temperature in this circuit depresses the pH and there might be pockets of equipment free of amine. Without the benefits of amine, corrosion might be high. High turbulence, especially in the Stripper Reboiler can cause severe corrosion.

Poor amine quality can increase corrosion rates.

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3.7.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Piping elbow, bends, etc. where fluid velocity is high	Erosion due to impingement by solids and/or gas breakout	Erosion corrosion can happen even when the liquid velocity was calculated to be within the limit for single phase flow. CO_2 breakout may occur downstream of control valves Predictibility: FAIR

3.7.5 Inspection History – Highlights

3.7.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
Erosion	Areas of high turbulence where protective scale may be removed such as elbows, bends, downstream of valves	Check with UT/RT

3.7.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.7.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.7.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
Lean amine outlet from E-24603 A/B	[redacted] °C	Temperature	Higher Temperature increases gas breakout tendency and amine degradation.
Lean acid gas loading	[redacted] mol CO_2/mol amine	Loading	Actual acid gas loading can be much higher than calculated value, resulting in more severe corrosion.
Lean Solvent pH	> 10.5		
Solid Loadings	30 ppmw MAX, target < 10ppmw	TSS	Unfiltered solids can plug stripper trays, plate exchangers, increase rich outlet temperature and increase gas breakout tendency
Heat Stable Salts	< 1wt% of total solvent	HSS	Increases actual gas loading
Chlorides	< 1000 ppmw	Chloride	Chloride concentration increased risk of Cl SCC
ADIP-X solvent MDEA	[redacted] wt%	MDEA	Design
ADIP-X solvent DEDA	[redacted] wt%	DEDA	Design
ADIP-X solvent water	[redacted] wt%	H_2O	Water content of the amine can be determined by Karl Fischer analysis and should be checked at regular intervals. If the percent weight of amine in the solution is being monitored daily, the water content check by Karl Fischer can be performed two or three times a week. Otherwise, the water content should be checked at least once per day. It is recommended that water content be measured by each shift.

3.7.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.7.11 Recommendations and Material Changes

None

3.8 CC24603 – WARM LEAN AMINE

3.8.1 Circuit Description

Warm lean amine from the outlet of the Lean / Rich Amine Exchangers E-24602 A/B through the shell sides of the Lean Amine Coolers E-24604 A/B and the Lean Amine Trim Coolers E-24605 A/B plate exchanger to the Lean Amine Charge Pumps P-24602 A/B/C. Circuit also includes piping in units 240, 241, 242, 285.

Warm lean amine through the Lean Amine Filter V-24604, the Lean Amine Carbon Filter V-24608 and the Lean Amine Post Filter V-24609 to the Lean Amine Charge Pumps P-24602 A/B/C and to the Amine Make-Up Tanks TK-24601 and TK-24602.

Warm lean amine from the Lean Amine Charge Pumps P-24602 A/B/C to:

- Inlet nozzle to Amine Absorber 1 V-24118
- Inlet nozzle to Amine Absorber 2 V-24218
- Inlet nozzle to Amine Absorber 3 V-44118
- E-24602 A/B minimum flow line

Make-up amine from Amine Make-Up Tanks TK-24601 and TK-24602 through Amine Make-Up Pump P-24605 to the inlet of the Amine Stripper V-24601 and through the Amine Inventory Pump P-24604 to the junction with the make-up amine line to V-24601 and to the junction with the warm lean amine line tp P-24602 A/B/C.

3.8.2 Equipment and Materials

CC24603	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	413 to 1016	CS + 3mm CA +PWHT
Pipe	Pipe downsteam of FV-241075 to V-24118			304/304L SS dual certified
Pipe	Pipe downsteam of FV-242075 to V-24218			304/304L SS dual certified
Pipe	Pipe downsteam of FV-441075 to V-44118			304/304L SS dual certified
Equipment				
E-24604 A	Lean Amine Cooler			SH: CS + 3mm 304L SS Clad, tube and tubesheet Duplex 2205

CC24603	**Description**	**Normal Operating Conditions**		**Material**
E-24604 B	Lean Amine Cooler			SH: CS + 3mm 304L SS Clad, tube and tubesheet Duplex 2205
E-24605 A	Lean Amine Trim Cooler			CS Frame with 316L liner, 316/316L SS dual certified plates, EPDM gaskets
E-24605 B	Lean Amine Trim Cooler			CS Frame with 316L liner, 316/316L SS dual certified plates, EPDM gaskets
V-24604	Lean Amine Filter			CS + 3mm CA + PWHT Internals 316 or 316L SS
V-24608	Lean Amine Carbon Filter			CS + 3mm CA + PWHT Internals 316 or 316L SS
V-24609	Lean Amine Post Filter			CS + 3mm CA + PWHT Internals 316 or 316L SS
TK-24601	Amine Make-Up Tank			SH/BTM/RF: Duplex 2101 + 0.4mm CA Nozzles/Flanges: Duplex 2205 + 0.4mm CA
TK-24602	Amine Make-Up Tank			SH/BTM/RF: Duplex 2101 + 0.4mm CA Nozzles/Flanges: Duplex 2205 + 0.4mm CA
P-24602 A/B/C	Lean Amine Charge Pumps			Casing and Impeller are 316 SS
P-24604	Amine Inventory Pump			Casing and Impeller are 316 SS
P-24605	Amine Make-Up Pump			Casing and Impeller are 316 SS

3.8.3 Reasons for Materials of Construction

The circuit piping is constructed of carbon steel with 3mm corrosion allowance and is post weld heat treated. There are several sections of pipe that are 304/304L SS dual certified to to their connection with pressure vessels in other Circuits.

The plate exchangers are 316/316L SS dual certified. The Filters shells are also carbon steel with with 3mm corrosion allowance and is post weld heat treated

The carbon steel material, PWHT, is acceptable in a Lean Amine environment with CO_2.

The mixing point with the anti-foam (CC-24611) has a 304/304L SS tee.

The acid gas loading and quality of the lean amine will determine corrosivity.

The CO_2 partial pressure is low but the temperature remains is[redacted]C to E-24605 A/B. There is a risk of heat stable amine salts and solids, so corrosion can still be a concern.

3.8.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
General Piping and Equipment	Wet CO_2 Corrosion	More severe if organic acids, heat stable amine salts are present Carbon Steel corrosion rates are expected to be low in normal operating conditions.(<0.1mm/yr) Predictibility: GOOD
General Piping and Equipment	Amine Corrosion	Similar to CO_2 corrosion but at a reduced magnitude due to the inherent high pH nature of amine solution Predictibility: GOOD

3.8.5 Inspection History – Highlights

3.8.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
Water condensation/wet CO2 corrosion	Cold spots where condensation may occur in tight spots where amine is not present to increase pH and lower corrosion rates	Check with UT scan/RT

3.8.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
TBD	Anti-Foam injection into lean amine stream to V-24118	conc cell corrosion /
TBD	Anti-Foam injection into lean amine stream to V-24218	conc cell corrosion
TBD	Anti-Foam injection into lean amine stream to V-44118	conc cell corrosion / Quill Vibration

3.8.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.8.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A
Tag	Min/Max	Variable type	Reasons/Causes/Actions
Lean amine outlet from E-24603 A/B	[redacted] °C	Temperature	Higher Temperature increases gas breakout tendency and amine degradation.
Lean acid gas loading	[redacted] mol CO_2/mol amine	Loading	Actual acid gas loading can be much higher than calculated value, resulting in more severe corrosion.
Lean Solvent pH	> 10.5		
Solid Loadings	30 ppmw MAX, target < 10ppmw	TSS	Unfiltered solids can plug stripper trays, plate exchangers, increase rich outlet temperature and increase gas breakout tendency
Heat Stable Salts	< 1wt% of total solvent	HSS	Increases actual gas loading
Chlorides	< 1000 ppmw	Chloride	Chloride concentration increased risk of Cl SCC
ADIP-X solvent MDEA	[redacted] wt%	MDEA	Design
ADIP-X solvent DEDA	[redacted] wt%	DEDA	Design
ADIP-X solvent water	[redacted] wt%	H_2O	Water content of the amine can be determined by Karl Fischer analysis and should be checked at regular intervals. If the percent weight of amine in the solution is being monitored daily, the water content check by Karl Fischer can be performed two or three times a week. Otherwise, the water content should be checked at least once per day. It is recommended that water content be measured by each shift.

3.8.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
Lean	Line from V-24609 to TK-24601	This NNF line is carbon steel and should be a

Amine		suitable material. However, it is a deadleg and therefore may experience condensation which could become an issue in localized areas.
Lean Amine	Line from V-24605 to TK-24601	This NNF line is carbon steel and should be a suitable material. However, it is a deadleg and therefore may experience condensation which could become an issue in localized areas.

3.8.11 Recommendations and Material Changes

None

3.9 CC24604 – stripper reflux

3.9.1 Circuit Description

Treated CO_2 gas from the top of the Amine Stripper V-24601 through the shell side of the Stripper Overhead Condensers E-24601 A/B to the Stripper Reflux Drum V-24602. Water from the bottom of V-24602 through the Stripper reflux Pumps P-24603 A/B returning to V-24601 and streaming to the WWTP in Unit 271.

The Circuit includes the section of V-24602 below the demister pad.

3.9.2 Equipment and Materials

CC24604	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	[redacted]	46 to 54	304/304L SS dual certified
Equipment				
V-24601	Amine Stripper			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
V-24602	Stripper Reflux Drum			CS + 3mm 304L SS Clad, Internals 316 or 316L SS
E-24601 A	Stripper Overhead Condenser			SH: CS + 3mm 304L SS Clad, tube and tubesheet Duplex 2205
E-24601 B	Stripper Overhead Condenser			SH: CS + 3mm 304L SS Clad, tube and tubesheet Duplex 2205
P-24603 A/B/	Stripper RefluxPumps			Casing and Impeller are 316 SS

3.9.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration. The Amine Stripper and Stripper Reflux Drum shell are carbon steel with 304L cladding. This material was selected due to the wet CO_2.environment.

3.9.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Piping elbow, bends, etc. where fluid velocity is high	Erosion due to impingement by solids and/or gas breakout	Erosion corrosion can happen even when the liquid velocity was calculated to be within the limit for single phase flow. CO_2 breakout may occur downstream of control valves Predictibility: GOOD

3.9.5 Inspection History – Highlights

3.9.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.9.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.9.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.9.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	

3.9.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
Waste Water	From the block valve on the discharge line of P-24607 to the junction with the waste water line from P-24603 A/B.	Given that this is a NNF line Carbon Steel should be a suitable material. However, it is a deadleg therefore if it is not drained properly it could become an issue in localized areas.

3.9.11 Recommendations and Material Changes

None

3.10 CC24605 –CO_2 GAS TO COMPRESSION

310.1 Circuit Description

Stripped dry CO_2 gas from the top of the Stripper Reflux Drum V-24602 to the inlet of the Compressor Suction KO Drum V-24701. The Circuit includes the section of V-24602 above the demister mat.

3.10.2 Equipment and Materials

CC24605	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	36	46	304/304L SS dual certified
Equipment				
V-24602	Stripper Reflux Drum			CS + 3mm 304L SS Clad, Internals 316 or 316L SS

3.10.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration. The Stripper Reflux Drum shell is carbon steel with 304L cladding This material was selected due to the CO_2.environment.

The stripped dry gas, containing mainly CO_2, minor water vapour but no liquid water, should not be corrosive.

3.10.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
General Piping and Equipment	Corrosion Fatigue	It is prudent for operators and inspectors to be particularly sensitive to observations or reports of pressure or temperature fluctuation or piping vibration and make changes to eliminate them.

3.10.5 Inspection History – Highlights

3.10.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.10.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.10.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.10.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.10.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.10.11 Recommendations and Material Changes

None

3.11 CC24106, CC24206, CC24606, CC44106 – Anti-foam injection

3.11.1 Circuit Description

Anti-foam from the tote tank through the Anti-Foam Injection Pump P-24606 is streamed to the following injection points:

- Between the Lean / Rich Amine Exchangers E-24602 A/B and the Amine Stripper V-24601
- The lean amine line to V-24118
- The lean amine line to V-24218
- The lean amine line to V-44118

This anti-foam injection system is used intermittently to control upset conditions. The anti-foam recommended is MAX-AMINE 70B produced by GE Betz Canada.

3.11.2 Equipment and Materials

CC24106, CC24206, CC44106	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping	Anit-Foam			304/304L SS dual certified

3.11.3 Reasons for Materials of Construction

The circuit piping is manufactured of 304/304L SS dual certified. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration.

During upset conditions, the injection point between the Lean / Rich Amine Exchangers E-24602 A/B and the Amine Stripper V-24601 will be used normally. The injection point connection is 304/304L SS to 304/304L SS with a 316 SS quill.

The injection points in the lean amine lines are a 304/304L SS connection into a 304/304L SS tee in the amine lines with a 316 SS quill.

This system is not expected to be corrosive.

3.11.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
N/A	N/A	N/A

AREAS AFFECTED	DEGRADATION	NOTES
Chemical injection	Mixing point	No corrosion is expected as the materials are chosen specifically to be resistant to the chemicals. The CS piping downstream of the SS mixing tee may exhibit localized corrosion..

3.11.5 Inspection History - Highlights

3.11.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.11.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
TBD	Anti-Foam injection into rich amine stream to V-24601	Localized / Quill Vibration
TBD	Anti-Foam injection into lean amine stream to V-24118	Localized / Quill Vibration
TBD	Anti-Foam injection into lean amine stream to V-24218	Localized / Quill Vibration
TBD	Anti-Foam injection into lean amine stream to V-44118	Localized / Quill Vibration

3.11.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.11.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.11.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.11.11 Recommendations and Material Changes

None

3.12 CC24607 – Recovered Amine

3.12.1 Circuit Description

The Amine Drain Drum V-24606 is connected to a closed drain system that collects lean and rich amine from fixed and rotating equipment.

Liquids from V-24606 through the Drained Amine Filter V-24605 are included in this circuit.

Liquids from V-24701 the compressor suction KO Drum are included in this circuit.

3.12.2 Equipment and Materials

CC24607	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping from Amine Drain Drum	Variable	Variable	CS + 3mm CA + PWHT
Equipment				
V-24605	Drained Amine Filter			CS + 3mm CA Internals 316 or 316L SS
V-24606	Amine Drain Drum			CS + 3mm CA + PWHT Internals 316 or 316L SS
P-24607	Amine Drain Pump			Casing and Wetted Parts are 316 SS
V-24701	Compressor suction KO Drum			CS + 3mm SS304L clad

3.12.3 Reasons for Materials of Construction

The circuit piping to V-24606 is manufactured of 304/304L SS dual certified.. The piping has a 0.4mm corrosion allowance to accommodate very low corrosion rates and ABSA registration. The rest of the piping and the drain drum are made with carbon steel with post weld heat treatment to guard against amine stress corrosion cracking.

The liquids collected include lean amine, rich amine and various water streams.

3.12.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Amine Drain Drum	Under deposit corrosion	Amine quality will determine tendency for fouling. Predictibility: GOOD

3.12.5 Inspection History - Highlights

3.12.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
Pitting	Wherever sludge deposits can form, such in the bottom of the Amine Drain Drum.	Visual inspection and pit gauge measurements during internal inspections.

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.12.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.12.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.12.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.12.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

Recovered Amine	Line from V-24606 to V-24601	This NNF line is carbon steel and should be a suitable material. However, it is a deadleg and therefore may experience condensation which could become an issue in localized areas.

3.12.11 Recommendations and Material Changes

None

3.13 CC24001, CC24107, CC24207, CC24608, CC24707, CC24806, CC28201, CC28506, CC4401, CC44107 – cooling water

3.13.1 Circuit Description

This circuit contains the cooling water and includes the supply and return headers and all of the interconnecting piping and condensers/coolers in Plants 246. **NOTE**: The utilities portion of the unit Corrosion Manuals will be updated in full once there Site Wide Utilities and Offsites Corrosion Manual is updated. Circuit also includes piping in pipe rack 285 and piping in 440

PFD 240.0001.000.040.001
PFD 241.0001.000.040.001
PFD 242.0001.000.040.001
PFD 246.0001.000.040.001
PFD 247.0001.000.040.001
PFD 248.0001.000.040.001
PFD 282.0001.000.040.001
PFD 441.0001.000.040.001

3.13.2 Equipment and Materials

CC24001, CC24107, CC24207, CC24707, CC24806, CC28201, CC44107	**Description**	**Normal Operating Conditions**		**Material**
		T (C)	**P (kPa)**	
Piping				
General Piping	Piping through out circuit	25-43		CS with 1.5 mm CA
Equipment				
E-24129	Absorber 1 Circulating Water Cooler			CH: CS + 3mm 304L SS Clad TS: Super Duplex 2507 Tubes: Super Duplex 2507 + 0.38mm CA

CC24001, CC24107,	Description	Normal Operating Conditions		Material
E-24229	Absorber 2 Circulating Water Cooler			CH: CS + 3mm 304L SS Clad TS: Super Duplex 2507 Tubes: Super Duplex 2507+ 0.38mm CA
E-44129	Absorber 3 Circulating Water Cooler			CH: CS + 3mm 304L SS Clad TS: Super Duplex 2507 Tubes: Super Duplex 2507+ 0.38mm CA
E-24601 A/B	Stripper Overhead Condenser			CH: CS + 3mm 304L SS Clad TS: Duplex 2507 Tubes: Duplex2205+ 0.38mm CA
E-24604 A/B	Lean Amine Coolers			CH: CS + 3mm 304L SS Clad TS: Duplex 2205 Tubes: Duplex 2205+ 0.38mm CA
E-24605 A/B	Lean Amine Trim Coolers			Frame: CS Plates: 316/316L SS dual certified
E-24607	Condensate Cooler			CH: CS + 3mm CA TS: CS + 6mm CA Tubes: CS+ 0.8mm CA
E-24701	Compressor Cooler	100	188	CH: CS + 3mm 304L SS Clad Tubes: Duplex2205+ 0.38mm CA
E-24701	Compressor Cooler	100	376	CH: CS + 3mm 304L SS Clad Tubes: Duplex2205+ 0.38mm CA

CC24001, CC24107,	**Description**	**Normal Operating Conditions**		**Material**
E-24701	Compressor Cooler	100	728	CH: CS + 3mm 304L SS Clad Tubes: Duplex2205+ 0.38mm CA
E-24701	Compressor Cooler	100	1379	CH: CS + 3mm 304L SS Clad Tubes: Duplex2205+ 0.38mm CA
E-24804A-E	Lean TEG Cooler	94	5587	CS + 3mm CA
E-44005				
P-24611 A/B	Cooling Water Booster Pumps			Casing and Impeller are CS

3.13.3 Reasons for Materials of Construction

Materials of construction for this circuit are not expected to experience any un-anticipated corrosion as long as the cooling water chemical treatment program is strictly adhered to.

The Upgrader cooling water corrrosion rate has been measured between 0.25 to 0.40 mm/year.

3.13.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	**DEGRADATION MECHANISM**	**NOTES**

3.13.5 Inspection History – Highlights

Refer to inspection history of base plant exchangers for insight about potential corrosion issues with the cooling water system.

3.13.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	**Location**	**Comments (e.g. how much, etc.)**

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.13.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
None	None	None

3.13.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.13.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	See U&O Corrosion Manual for ESP Variables. Cooling Water is not monitored specifically within Unit 246.

3.13.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.13.11 Recommendations and Material Changes

Consider installing magnesium anodes in the shell and tube exchanger channels to mitigate the observed cooling water corrosion rates

3.14 CC24609 – MEDIUM PRESSURE STEAM

3.14.1 Circuit Description

This circuit contains all of the 350 kPa saturated steam equipment and piping within Unit 240,241, 242 246, 247, 440 and 441.. This includes the tube sides of the Stripper Reboilers E-24603 A/B, the Stripper Reboiler Condensate Pots V-24603 A/B and the Heating Coils in Amine Make-Up Tanks TK-24601 and TK-24602.

3.14.2 Equipment and Materials

CC24609	Description	Normal Operating Conditions		Material
		T (C)	P (kPa)	
Piping				
General Piping	Piping through out circuit	145	320	CS + 1.5mm CA
Equipment				
E-24603 A	Stripper Reboiler			CH: CS + 3mm 304L SS Clad TS: 304L SS Tubes: 316/316L SS dual certified + 0.6mm CA
E-24603 B	Stripper Reboiler			CH: CS + 3mm 304L SS Clad TS: 304L SS Tubes: 316/316L SS dual certified + 0.6mm CA
V-24603 A	Stripper Reboiler Condensate Pot			CS + 3mm CA
V-24603 B	Stripper Reboiler Condensate Pot			CS + 3mm CA
Heating Coil	Amine Make-Up Tank TK-24601			Duplex 2205 + 0.4mm CA
Heating Coil	Amine Make-Up Tank TK-24602			Duplex 2205 + 0.4mm CA

3.14.3 Reasons for Materials of Construction

Carbon Steel is widely applied for the piping and if the Steam chemistry is maintained within the limits set by the water treatment philosophy then Carbon Steel is a suitable material for this service.

The alloy tubes in the Stripper reboilers are for shell side (rich amine) corrosion mitigation.

The alloy tubes in the Amine Make-Up Tank Heating Coils are for tank side (lean amine) corrosion mitigation.

3.14.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Piping and Equipment	Wet CO_2 Corrosion	Localized carbonic acid corrosion can occur in areas where the neutralizing amine does not reach. Areas of greatest concern are dew point, drains, etc.
Piping and Equipment	Oxygen Pitting	Oxygen pitting could be due to poor deaeration or a leak into the system.

3.14.5 Inspection History – Highlights

Refer to inspection history of base plant equipment and piping for insight about potential corrosion issues with the steam systems.

3.14.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.14.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
None	None	None

3.14.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.14.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.14.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.14.11 Recommendations and Material Changes

None

3.15 CC24610 – CLEAN CONDENSATE

3.15.1 Circuit Description

From the unit battery limit (via the TEG Stripper Reboiler Condensate Pot V-24805), HP Condensate to the Condensate Flash Drum V-24607.

LP Condensate from the Stripper reboiler Condensate Pots V-24603 A/B through the LP Condensate / Demin Water Exchangers E-24606 A/B to the Condensate Flash Drum V-24607.

LP Condensate from the Amine Make-Up Tanks TK-24601 and TK-24602 heating coils to the Condensate Flash Drum V-24607.

Recovered Clean Condensate from the Condensate Flash Drum V-24607 through the Recovered Clean Condensate Pumps P-24608 A/B is used for the water wash makeup (see water wash CC24104;

- Through the shell side of the Condensate Cooler E-24607 to the Water Make-up Pumps P-24609 A/B and to the junction with the purge water to the Stripper Reflux Drum V-24602,
- From the Water Make-up Pumps P-24609 A/B to the inlets of the Absorber Water Wassh Vessels V-24119 and V-24219.
- To TK-25101 and to the control valve CV-xxxxx in the line to the Potentially Oily Condensate recovery in WWTP Unit 271,
- To the inlets of the Amine Make-Up Tanks TK-24601 and TK-24602.

3.15.2 Equipment and Materials

CC24610	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
General piping	Piping throughout the circuit	35 to 255	425 to 4210	CS + 1.5mm CA
At TK-24601 and TK-24602	Condensate for amine mixing	74	425	CS + 3.0mm CA
Equipment				
E-24606 A	LP Condensate / Demin Water Exchanger			CS Frame, 316/316L SS dual certified plates, EPDM gaskets
E-24606 B	LP Condensate / Demin Water Exchanger			CS Frame, 316/316L SS dual certified plates, EPDM gaskets
E-24607	Condensate Cooler			SH: CS + 3mm CA
V-24607	Condensate Flash Drum			CS + 3mm CA

CC24610	Description	Normal Operating Conditions		Material
P-24608 A/B	Recovered Clean Condensate Pumps			Casing and Impeller are CS
P-24609 A/B	Water Make-Up Pumps			Casing and Impeller are CS

3.15.3 Reasons for Materials of Construction

Carbon steel can provide adequate corrosion protection of steam condensate piping if the corrosion control chemistry is in place. Corrosion protection can be through neutralizing, filming or passivating amines.

The circuit piping downstream of V-24607 operates around 74°C, making it susceptible to corrosion under insulation (CUI) if the low chloride content insulation specification has not been applied.

3.15.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Condensate Piping	FAC CO_2 Oxygen Pitting	FAC and CO_2 mechanisms can be active when the BFW and steam condensate chemistry programs are not working as designed. Both are accelerated by high and turbulent velocity water. Oxygen pitting could be due to poor deaeration or a leak into the system.
General Piping and Equipment	Corrosion Fatigue	It is prudent for operators and inspectors to be particularly sensitive to observations or reports of pressure or temperature fluctuation or piping vibration and make changes to eliminate them.

3.15.5 Inspection History – Highlights

Refer to inspection history of base plant equipment and piping for insight about potential corrosion issues with the clean condensate system.

3.15.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
CUI	Areas where insulation is damaged allowing water ingress.	Visual inspection looking for damaged insulation and thermography of insulated lines looking for cooler areas which couldf indicate water ingress.

3.15.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.15.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.15.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.15.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
Recovered Clean Condensate	Line from P-24608 A/B to TK-24601	This NNF line is carbon steel and should be a suitable material. However, it is a deadleg and therefore may experience condensation which could become an issue in localized areas.

3.15.11 Recommendations and Material Changes

None

3.16 CC44108 – boiler feedwater

3.16.1 Circuit Description

The Circuit starts at the Boiler Feedwater header through the Wash Water Make-Up Cooler E-44014 to the inlet of the Absorber 3 Wash Water Vessel V-44119.

3.16.2 Equipment and Materials

CC44108	Description	Normal Operating Conditions		Material
		T (°C)	P (kPa)	
Piping				
General Piping	From BL to inlet of E-44014	121	7000	CS + 1.5mm CA
General Piping	From E-44014 outlet to V-44119	36	2961	CS + 3.0mm CA
Equipment				
E-44014	Wash Water Make-Up Cooler			SH: CS + 3.0mm CA

3.16.3 Reasons for Materials of Construction

If the BFW chemistry is maintained within the limits set by the water treatment philosophy then Carbon Steel is a suitable material for this service.

3.16.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Condensate Piping	FAC CO_2 Oxygen Pitting	FAC and CO_2 mechanisms can be active when the BFW and steam condensate chemistry programs are not working as designed. Both are accelerated by high and turbulent velocity water. Oxygen pitting could be due to poor deaeration or a leak into the system.

3.16.5 Inspection History – Highlights

Refer to inspection history of base plant equipment and piping for insight about potential corrosion issues with the BFW system.

3.16.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.16.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.16.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.16.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.16.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.16.11 Recommendations and Material Changes

None

3.17 CC24611 – DEMINERALIZED WATER

3.17.1 Circuit Description

Demineralized water from the unit battery limit through the Demin Water Supply Pumps P-24610 A/B and the LP Condensate / Demin Water Exchangers E-24606 A/B plate exchangers returning to the Deaerator V-25102. Circuit also includes piping in units 251 and 285.

3.17.2 Equipment and Materials

CC-1074	Description	Normal Operating Conditions		Material
		T (°C)	P (kPa)	
Piping				
General Piping	Stainless Steel piping used for deminerilized water	22	84	304/304L SS dual certified
Equipment				
E-24606 A	LP Condensate / Demin Water Exchanger			CS Frame, 316/316L SS dual certified plates, EPDM gaskets
E-24606 B	LP Condensate / Demin Water Exchanger			CS Frame, 316/316L SS dual certified plates, EPDM gaskets
P-24610 A/B	Demin Water Supply Pumps			Casing and Impeller are 316 SS

3.17.3 Reasons for Materials of Construction

Demineralized water can be a considerable corrosive service for Carbon Steel. As a result 304 SS has been used for all demineralized water piping.

3.17.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Demin Piping	Demin Water Corrosion	This type of corrosion can be very aggressive to carbon steel.

3.17.5 Inspection History – Highlights

Refer to inspection history of base plant equipment and piping for insight about potential corrosion issues with the demineralized water system.

3.17.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.17.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.17.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.17.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.17.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.17.11 Recommendations and Material Changes

None

3.18 CC24108, CC24208, CC44109 – HYDROCARBON FLARE

3.18.1 Circuit Description

This Circuit includes the various flare lines within the Unit battery limits.

3.18.2 Equipment and Materials

CC24108, CC24208, CC44109	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
Flare piping	H_2 Raw Gas to Flare from PV-241067	35	2894	CS + 3mm CA
Flare piping	H_2 Raw Gas to Flare from PV-242067	35	2894	CS + 3mm CA
Flare piping	H_2 Raw Gas to Flare from PV-441067	35	2894	CS + 3mm CA
Equipment				
None				

3.18.3 Reasons for Materials of Construction

The flare lines are manufactured from carbon steel with 3mm corrosion allowance. Under normal operating conditions, the flare lines will not be exposed to the process fluids and gases.

3.18.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Drains and Low Points	Wet CO_2 Corrosion	Treated gas will contain CO_2 not absorbed without the benefit of the amine high pH. Predictibility: GOOD

3.18.5 Inspection History – Highlights

Refer to inspection history of base plant piping for insight about potential corrosion issues with the flare header systems.

3.18.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
Wet CO_2 Corrosion	If the PV-241067, PV-242067, or PV-441067 are passing, areas where water could condense could result in localized corrosion.	Check for control valve leakage to flare header. Check with UT/RT areas where condensation can occur.

3.18.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.18.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	N/A

3.18.9 ESP Variables

Tag	Min/Max	Variable type	Reasons/Causes/Actions
N/A	N/A	N/A	N/A

3.18.10 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD	TBD	TBD

3.18.11 Recommendations and Material Changes

None

3.19 CC24612, CC24701 – Compression Stages 1-6

3.19.1 Circuit Description

CO_2 leaving the Amine Stripper Reflux Drum V-24602 goes to the inlet of the 1st stage scrubber V-24701 and through to the 6th stage of compression before dehydration

This circuit only covers 6 stages of compression and all associated piping in between. The CO_2 is in the gas phase and as this stage is before the dehydration there is a risk of wet CO_2 corrosion.

PFD 246.0001.000.040.001
PFD 247.0001.000.040.001
PFD 247.0001.000.040.002

3.19.2 Equipment and Materials

CC24612, CC24701	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
Piping leaving V-24602 to V-24701	CO2 Vapour Piping	36	41	Dual certified 304 + 0.4mm
Piping from V-248003	CO2 vapour piping	53	41	Dual certified 304 + 0.4mm
Piping from V-24701 to C24701A	CO2 vapour piping	36	41	Dual certified 304 + 0.4mm
Piping from C24701A to E24701	CO2 vapour piping	99	176	Dual certified 304 + 0.4mm
Piping from E24701 to C24701B	CO2 Vapour Piping	42	164	Dual certified 304 + 0.4mm
Piping from C24701B to E24702	CO2 Vapour Piping	90	361	Dual certified 304 + 0.4mm
Piping from 24702 to C24701C	CO2 Vapour Piping	42	345	Dual certified 304 + 0.4mm
Piping from C24701C to E24703	CO2 Vapour Piping	107	815	Dual certified 304 + 0.4mm

CC24612, CC24701	Description	Normal Operating Conditions		Material
Piping from E24703 to C24701D	CO2 Vapour Piping	42	795	Dual certified 304 + 0.4mm
Piping from C24701D to E24704	CO2 Vapour Piping	92	1467	Dual certified 304 + 0.4mm
Piping from E24704 to C24701E	CO2 Vapour Piping	42	1432	Dual certified 304 + 0.4mm
Piping from C24701E to E24705	CO2 Vapour Piping	97	2689	Dual certified 304 + 0.4mm
Piping from E24705 to C24701F	CO2 Vapour Piping	42	2646	Dual certified 304 + 0.4mm
Piping from C24701F to E24706	CO2 Vapour Piping	76	3912	Dual certified 304 + 0.4mm
Equipment				
V-24701	Compressor Suction KO drum	36	41	CS + 304L clad, Internals 316L
V-24702	Compressor Suction KO drum	42	164	CS + 304L clad, Internals 316L
V-24703	Compressor Suction KO drum	42	345	CS + 304L clad, Internals 316L
V-24704	Compressor Suction KO drum	42	795	CS + 304L clad, Internals 316L
V-24705	Compressor Suction KO drum	42	1432	CS + 304L clad, Internals 316L
V-24706	Compressor Suction KO drum	42	2646	CS + 304L clad, Internals 316L
C-24701A	Compressor	99	176	See Compressor Design
C-24701B	Compressor	90	361	See Compressor Design
C-24701C	Compressor	107	815	See Compressor Design
C-24701D	Compressor	92	1467	See Compressor Design
C-24701E	Compressor	97	2689	See Compressor Design
C-24701-F	Compressor	76	3912	See Compressor Design

CC24612, CC24701	Description	Normal Operating Conditions		Material
E-24701	Compressor cooler	99	176	SH CS +3mm 304L clad, CH: CS+3mm CA, TS Duplex 2205, Tube Duplex 2205 +0.38mm CA
E-24702	Compressor cooler	90	361	SHI CS +3mm 304L clad, CH: CS+3mm CA, TS Duplex 2205, Tube Duplex 2205 +0.38mm CA
E-24703	Compressor cooler	107	815	SHI CS +3mm 304L clad, CH: CS+3mm CA, TS Duplex 2205, Tube Duplex 2205 +0.38mm CA
E-24704	Compressor cooler	92	1467	SHI CS +3mm 304L clad, CH: CS+3mm CA, TS Duplex 2205, Tube Duplex 2205 +0.38mm CA
E-24705	Compressor cooler	97	2689	SHI CS +3mm 304L clad, CH: CS+3mm CA, TS Duplex 2205, Tube Duplex 2205 +0.38mm CA
E-24706	Compressor cooler	76	3912	HDR 304L, Tube 304L+0.38mm CA

3.19.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate ASME code.

CO_2 corrosion is not expected due to suction scrubbers, but may be present in upsets.

3.19.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Compressor	Vibration	A form of mechanical fatigue in which cracks produced as result of dynamic loading due to vibration Predictability: GOOD

3.19.5 Inspection History – Highlights

None

3.19.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)

N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.19.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.19.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.19.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.19.10 Recommendations and Material Changes

None

3.20 CC24702, CC24801 – Compression Stages 7-8

3.20.1 Circuit Description

Dehydrated gas leaving the TEG absorber V-24801 to the 7th stage scrubber V-24708 and through the 7 & 8th stage compressors and on to the pipeline

This circuit only covers 2 stages of compression and all associated piping in between TEG absorber to the pipeline

PFD 247.0001.000.040.002
PFD 247:0001.000.040.003
PFD 248.0051.000.059.001

3.20.2 Equipment and Materials

CC24702, CC24801	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
From V-24801 through V-24708 to	Dry CO2 piping	39	3792	304 + 0.4mm
From V-24708 to C24701G	Dry CO2 piping	38	3172	304 + 0.4mm
From C24701G to C24701H	Dry CO2 piping	86	6461	304 + 0.4mm
From C24701H to E24707A/B	Dry CO2 piping	121	9200	304 + 0.4mm
From E24707A/B to pipeline	Dry CO2 piping	43	9000	304 + 0.4mm
Equipment				
V-24801	TEG Absorber	38	4907	SH CS+3mm304L Clad, Int 316L
V-24708	7th Stage Compressor KO drum	38	4876	SH CS+3mm 304L Clad, Int 316L
C-24701G	7th Stage Compressor	38	4876	See compressor design
C-24701H	8th Stage Compressor	92	8899	See compressor design
E-24707A/B	Compressor Aftercooler	137	14000	HDR 304L, Tube 304L+0.38CA

3.20.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate ASME code.

CO_2 corrosion is not expected due to dehydration, but may be present in upsets.

3.20.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Compressor	Vibration	A form of mechanical fatigue in which cracks produced as result of dynamic loading due to vibration Predictability: GOOD

3.20.5 Inspection History – Highlights

N/A

3.20.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.20.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.20.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.20.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.20.10 Recommendations and Material Changes

None

3.21 CC24703 Knock Out Water Drains

3.21.1 Circuit Description

KO Water from V-24702, V-24703, V-24704, V-24705, V-24706 & V-24707 collected in common line and going to drains

PFD 247.0001.000.040.001
PFD 247.0001.000.040.002

3.21.2 Equipment and Materials

CC24703	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
Piping from suction scrubbers to drains	All wet CO2 liquid			SS304 + 0.4mm
Equipment				
V-24702	Suction Scrubber			CS + 304L clad, Internals 316L
V-24703	Suction Scrubber			CS + 304L clad, Internals 316L
V-24704	Suction Scrubber			CS + 304L clad, Internals 316L
V-24705	Suction Scrubber			CS + 304L clad, Internals 316L
V-24706	Suction Scrubber			CS + 304L clad, Internals 316L
V-24707	Suction Scrubber			CS + 304L clad, Internals 316L

3.21.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate ASME code. Liquid will contain high amounts of dissolved CO_2 making it extremely corrosive.

3.21.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.21.5 Inspection History – Highlights

N/A

3.21.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.21.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.21.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.21.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.21.10 Recommendations and Material Changes

None

3.22 CC24704, CC24802 – Knockout TEG

3.22.1 Circuit Description

TEG collected from V-24708 and returned to V-24803

PFD 247.0001.000.040.002
PFD 248.0001.000.040.001

3.22.2 Equipment and Materials

CC24704, CC24802	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
Piping from V-24708 to V-24803	KO TEG piping	55	273	SS304L + 0.4mm
Equipment				
V-24708	7th Stage suction scrubber	38	4876	CS + 304L clad, Internals 316L
V-24803	TEG flash drum	55	273	CS + 304L clad, Internals 316L

3.22.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate ASME code.

3.22.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Internal	conc cell corrosion	Solids from recycled TEG can deposit in deadlegs in drain if filter does not remove them Predictability: GOOD

3.22.5 Inspection History – Highlights

N/A

3.22.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.22.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.22.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	

3.22.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.22.10 Recommendations and Material Changes

None

3.23 CC24614 – Amine Drain

3.23.1 Circuit Description

The Amine Drain Drum V-24606 is connected to a closed drain system that collects lean and rich amine from fixed and rotating equipment. The circuit is all piping and equipment leaving V-24606

PFD 246.0001.000.040.003

3.23.2 Equipment and Materials

CC24614	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
Piping V-24606 to drain collection	Amine drain piping	36	41	CS + 3mm PWHT
Equipment				
V-24606	Amine Drain Drum	60	5	SH CS+6mmCA+PWHT

3.23.3 Reasons for Materials of Construction

The circuits is constructed of carbon steel with 3mm CA and pwht, the corrosion rate is expected to be low and PWHT reduces risk of amine cracking.

3.23.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.23.5 Inspection History – Highlights

N/A

3.23.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.23.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.23.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
N/A	N/A	

3.23.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.23.10 Recommendations and Material Changes

None

3.24 CC24803 – Rich TEG

3.24.1 Circuit Description

TEG leaving the absorber V-24801 to the TEG stripper condenser, through to the TEG flash drum V-24803 and through the lean rich heat exchanger E-24803 and onto the TEG stripper V-24802

PFD 248.0001.000.040.001

3.24.2 Equipment and Materials

CC24803	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping				
V-24801 to E24801	TEG piping	36	498	SS304 + 0.4mm
E24801 to V-24803	TEG piping	74	498	Tubes and tubesheet Duplex 2205
V-24803 to E24803	TEG piping	55	164	SS304 + 0.4mm
E24803 to V-24802	TEG piping	167	203	SS304 + 0.4mm
Equipment				
V-24801	TEG Absorber	38	4907	CS + 304L clad, Removable internals 316L
E24801	TEG stripper condenser	74	498	CS + 304L clad, Removable internals 316L
E24802	TEG stripper reboiler	204	8	Top CS + 304L clad, Removable internals 316Ti
V-24802	TEG stripper	204	8	Top CS + 304L clad, Removable internals 316L, Bot CS + 304L clad,
V-24803	TEG flash drum	55	273	CS + 304L clad, Removable internals 316L

3.24.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4mm corrosion allowance to accommodate ASME code.

CO_2 corrosion is not expected due to suction scrubbers, but may be present in upsets.

3.24.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Internal	CO2 corrosion	Internal corrosion due to CO2 concentrated amine. 304 is resistanct to CO2 corrosion so no general corroson Predictability: GOOD
Internal	Crevice corrosion	Where solids can build at flanges and deposit. Predictability: GOOD
External	CUI corrosion.	Insulation leaching chlorides and allowing concentration of chlorides and CL SCC. Visual inspection and monitoring will highlight areas of concern Predictability: GOOD

3.24.5 Inspection History – Highlights

None

3.24.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.24.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.24.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.24.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.24.10 Recommendations and Material Changes

None

3.25 CC24804 - Lean TEG

3.25.1 Circuit Description

From V-24806 through the lean rich heat exchange E-24803 via pump P-24801A/B and V-24804A/B the lean filter to the E-24804 the lean cooler and returning to the TEG absorber V-24801.

PFD 248.0001.000.040.001

3.25.2 Equipment and Materials

CC24804	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping	General Piping unless specified below			SS304 + 0.4mm
V-24806 to E24803	Piping			SS304 + 0.4mm
E24803 to E24804	Piping			CS + 3mm
E-24804 to V-24801	Piping			CS + 3mm
Equipment				
V-24806	TEG surge drum	198	8	CS + 316L clad
E-24803	Lean/Rich TEG exchanger	198	70	CS + 304L clad, Internals 316L
V-24804	Lean TEG filter	94	5742	CS + 304L clad, Internals 316L
E-24804	Lean TEG cooler	39	5587	CS
V-24801	TEG Absorber	38	4907	CS + 304L clad, Internals 316L

3.25.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4 mm corrosion allowance to accommodate ASME code. Some piping is constructed with Carbon steel for lean teg sections.

CO_2 corrosion is not expected due to suction scrubbers, but may be present in upsets.

3.25.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Internal	Crevice corrosion	If the TEG is not filtered properly then solids can accumulate in the system. Where solids can build at flanges and deposit. Predictability: GOOD
Internal	Erosion Corrosion	If TEG is not filtered properly or the temperature is too high then solids can accumlate in system. This increases the risk of erosion corrosion. Predictability: GOOD

3.25. 5 Inspection History – Highlights

None

3.25.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.25.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.25.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.25.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.25.10 Recommendations and Material Changes

None

3.26 CC24613, CC24706 – CO_2 Vent

3.26.1 Circuit Description

From prior to inlet of V-24701 to S-24603 CO2 Vent Stack. Collects from Pipeline and exit of V-24706

PFD 246.0001.000.040.004
PFD 247.0001.000.040.001
PFD 247.0001.000.040.002

3.26.2 Equipment and Materials

CC24804	**Description**	**Normal Operating Conditions**		**Material**
		T (°C)	**P (kPag)**	
Piping	General Piping unless specified below			SS304 + 0.4mm
Equipment				
S-24603	CO2 Vent Stack			SS304

3.26.3 Reasons for Materials of Construction

The complete circuit is manufactured of stainless in anticipation of CO_2 corrosion. The piping has a 0.4 mm corrosion allowance to accommodate ASME code.

CO_2 corrosion is not expected due to suction scrubbers, but may be present in upsets.

3.26.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.26. 5 Inspection History – Highlights

None

3.25.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.26.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.26.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.26.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.26.10 Recommendations and Material Changes

None

3.26 CC24805, CC28501 – Low Temp HP Steam

3.26.1 Circuit Description

From low temp HP steam, through E24802 Tubes TEG stripper heater and

PFD 248.0001.000.040.001
PFD 285.0001.000.040.001

3.26.2 Equipment and Materials

CC24804	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
Piping	General Piping unless specified below			CS + 3mm
Equipment				
E-24802	Tube Side TEG stripper	160	8	CS + 316L clad

3.26.3 Reasons for Materials of Construction

The complete circuit is manufactured with CS. The piping has 3mm CA.

.

3.26.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.26. 5 Inspection History – Highlights

None

3.25.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.26.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.26.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.26.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.26.10 Recommendations and Material Changes

None

3.27 CC24615– Waste Water

3.27.1 Circuit Description

From V-24602 Stripper Reflux Drum through P-24603A/B pumps to junction with Oily condesate to Unit 271. Also from V-24606 Amine Drain Drum to WWTP Unit 271.

PFD 246.0001.000.040.001
PFD 246.0001.000.040.003
PFD 224.0001.000.040.004

3.27.2 Equipment and Materials

CC24804	**Description**	**Normal Operating Conditions**		**Material**
		T (°C)	**P (kPag)**	
Piping	Piping from V-24602			SS304 + 0.4mm CA
Piping	Piping from V-24606			CS + 3mm CA
Equipment				

3.27.3 Reasons for Materials of Construction

The complete circuit is manufactured with SS304 and CS

3.27.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.27. 5 Inspection History – Highlights

None

3.27.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.27.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.27.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.27.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.27.10 Recommendations and Material Changes

None

3.28 CCxxx21–LT HP Steam

3.28.1 Circuit Description

Low temperature high pressure (LTHP) steam is supplied to the RCDU from the low temperature HP steam header at normal conditions of 4150 kPag and 255°C. LTHP steam is used only in the TEG Stripper Reboiler.

3.28.2 Equipment and Materials

CCxxx21	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
All piping		255	4150	CS
Equipment				

3.28.3 Reasons for Materials of Construction

The circuit is manufactured with carbon steel

3.28.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.28. 5 Inspection History – Highlights

None

3.28.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.28.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.28.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.28.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.28.10 Recommendations and Material Changes

None

3.29 CCxxx22– Instrument Air

3.29.1 Circuit Description

Instrument air is supplied to HMU 1/2, HMU 3 and the RCDU at 700 kPag and 35°C for operation of pneumatic instruments during normal operation. The most significant user of instrument air in the RCDU is the CO2 Compressor, which requires 318 Sm3/h for seal gas

3.29.2 Equipment and Materials

CCxxx22	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
All piping		35	-	L.T. CS
Equipment				

3.29.3 Reasons for Materials of Construction

The circuit is manufactured with low temperature carbon steel

.26.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.29. 5 Inspection History – Highlights

None

3.29.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)

N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.29.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.29.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.29.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.29.10 Recommendations and Material Changes

None

3.30 CCxxx23– Nitrogen

3.30.1 Circuit Description

Nitrogen is supplied to HMU 1/2 and HMU 3 at 1100 kPag and 15°C for startup and shut-down purging of equipment and for purging of the flare header.

Nitrogen is supplied to the RCDU at 1100 kPag and 15°C for startup and shut-down purging of equipment, and pressure control and blanketing of the Amine Drain Drum, Amine Make-up Tanks and Condensate Flash Drum. Nitrogen is also used in the TEG Reboiler as a stripping gas

3.30.2 Equipment and Materials

CCxxx23	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
All piping		15	1100	L.T. CS
Equipment				

3.30.3 Reasons for Materials of Construction

The circuit is manufactured with low temperature carbon steel

3.30.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.30. 5 Inspection History – Highlights

None

3.30.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.30.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.30.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.30.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.30.10 Recommendations and Material Changes

None

3.31 CC24624– Natural Gas

3.31.1 Circuit Description

Natural gas is supplied to the CO2 compressor area of the RCDU at 1100 kPag and 15°C for building heating and air cooler bay heating

3.31.2 Equipment and Materials

CC24624	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
All piping		15	1100	L.T CS + 1.5mm CA
Equipment				

3.31.3 Reasons for Materials of Construction

The circuit is manufactured with low temperature carbon steel with 1.5mm corrosion allowance

3.31.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.31. 5 Inspection History – Highlights

None

3.31.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.31.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.31.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.31.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.31.10 Recommendations and Material Changes

None

3.32 CCxxx25– Lube Oil

3.32.1 Circuit Description

Lube Oil is supplied throughout the facility

3.32.2 Equipment and Materials

CC24624	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
All piping		80°C		304/304L SS dual certified with 0.4 mm CA
Equipment				
E-24230	LUBE OIL COOLER			
E-24710	LUBE OIL COOLER			
E-44135	LUBE OIL COOLER			
EH-24130	LUBE OIL HEATER			
EH-24230	LUBE OIL HEATER			
EH-24701A	LUBE OIL TANK HEATER			
EH-24701B	LUBE OIL TANK HEATER			
EH-44101	LUBE OIL HEATER			
P-24109A	LUBE OIL PUMP			
P-24109B	LUBE OIL PUMP			
P-24209A	LUBE OIL PUMP			
P-24209B	LUBE OIL PUMP			
P-44105A	LUBE OIL PUMP			
P-44105B	LUBE OIL PUMP			
S-24105	LUBE OIL SKID			
S-24205	LUBE OIL SKID			

CC24624	Description	Normal Operating Conditions		Material
S-24701	LUBE OIL SKID FOR COMPRESSOR PACKAGE			
S-24702	HYRDAULIC POWER PACK FOR XV-247001			
TK-24102	LUBE OIL TANK			
TK-24202	LUBE OIL TANK			
TK-24701	LUBE OIL RESERVOIR TANK			
TK-44105	LUBE OIL TANK			
V-24120A	LUBE OIL FILTER			
V-24120B	LUBE OIL FILTER			
V-24220A	LUBE OIL FILTER			
V-24220B	LUBE OIL FILTER			
V-24612A	MAKE-UP WATER PUMP LUBE OIL FILTER			
V-24612B	MAKE-UP WATER PUMP LUBE OIL FILTER			
V-24711A	LUBE OIL FILTER			
V-24711B	LUBE OIL FILTER			
V-44115A	LUBE OIL FILTER			
V-44115B	LUBE OIL FILTER			

3.32.3 Reasons for Materials of Construction

The circuit is manufactured with 304/304L SS dual certified with 0.4 mm corrosion allowance

3.32.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES

3.32. 5 Inspection History – Highlights

None

3.32.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
N/A	N/A	N/A

3.32.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.32.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.26.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism

TBD		TBD

3.32.10 Recommendations and Material Changes

None

3.33 CC24901 –Pipeline Leaving Upgrader Facilities, including Line Break Valves Risers #1 to #7 to Injection Wellheads Risers

3.33.1 Circuit Description

CO_2 leaving the Amine Gas Treater undergoes compression through a 8-stage compression train and a dehydrator to remove water (equivalent to 6 lb per MMSCF) before being sent to the CO2 pipeline.

This circuit covers the pipeline after the last compressor aftercooler E-24707A/B. It includes the pipeline the pipeline pig launchers/ receivers and the line break valves to the wellhead

3.33.2 Equipment and Materials

CC24901	Description	Normal Operating Conditions		Material
		T (°C)	P (MPa)	
Pipeline	12 NPS with 12.7 mm WT	36	12MPa	Low temperature carbon steel meeting minimum impact toughness of 60J at -45^{0}C with fracture apearance of 85%
Equipment				
Pipeline	Underground	36	12 MPa	Low temperature carbon steel CSA Z245.1 Gr 386 Cat II with 1.3mm CA and external Fusion bonded epoxy and cathodic protection
SP-24901/3	Pipeline Pig Launcher	36	12 MPa	Low temperature carbon steel, 1.3mm CA
SP-24902/4	Pipeline Pig Receiver	36	12 MPa	Low temperature carbon steel, 1.3mm CA
#1 to 6	Line Break Valves	36	12 MPa	Low temperature carbon steel
S-700201/2/3/	Wellsite Particle Filters	36	12 MPa	Low temperature carbon steel with 1.3mm CA and stainless steel internals

Note:

3.33.3 Reasons for Materials of Construction

The complete circuit is manufactured of carbon steel in anticipation of lack of corosion in the dense CO_2 phase. External corrosion is controlled through fusion bond epoxy coating and cathodic protection. The pipeline has a 1.3 mm corrosion allowance.

No CO_2 corrosion is expected under normal operating conditions. Upsets where water can be carried by the dense CO2 and accumulate at low spots leading to aqueous CO2 corrosion is not possible due to the stringent control within the plant.

3.33.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Pipeline and risers	External corrosion: Soil side corrosion	With time, the coating might become damaged and CP might not be adequate at some spots. Predictability: GOOD
	Internal (CO2)Corrosion	Unlikely as no free water is expected. Predictability: GOOD
	Earth movement	Unlikely due to anchors and riser design Predictability: GOOD
	External Corrosion Air to Soil interface	Ulikely due to riser design. Pipe is coated and insulated Predictability: GOOD
Line Break Valves	External corrosion	Above ground pipe not expected to corrode. Accessible for inspection Predictability: GOOD
	Internal Corrosion	Unlikely as no free water is expected. Predictability: GOOD
Pig launchers/Receivers	External corrosion	Above ground pipe not expected to corrode. Accessible for inspection Predictability: GOOD
	Internal Corrosion	Unlikely as no free water is expected. Predictability: GOOD

AREAS AFFECTED	DEGRADATION	NOTES
Wellsite Particle Filter	External corrosion	Above ground pipe not expected to corrode. Accessible for inspection
	Internal Corrosion	Not possible . Internals are stainless steel Predictability: GOOD

3.33. 5 Inspection History – Highlights

None	

3.33.6 Special Inspection Considerations – Equipment (in addition to CSA Z662)

Item	Location	Comments (e.g. how much, etc.)
LBV # 2		Pressure tests as required by regulators

Special Inspection Considerations – Piping (in addition to CSA Z662)

Item	Location	Comments (e.g. how much, etc.)

3.33.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	Methanol Injection	Oxygen corrosion

3.33.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References
Pipeline	Leak	Cooling by Joule-Thomson effect can lower temperature significantly. Special shutdown procedures are being developed.

3.33.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
N/A	N/A	

3.33.10 Recommendations and Material Changes

None

3.34 CC24902 Venting stack at line break valve location

3.34.1 Circuit Description

The venting double stack (H stack) is placed on the riser at each line break valve location to allow for emergency depressurization of the pipelines segments on both sides of the isolation valve. The vent system includes a bidrectional control valve for throttling and 2 normally closed blow down valves on the vent stacks.

3.34.2 Equipment and Materials

CC24902	Description	Normal Operating Conditions		Material
		T (°C)	P (kPag)	
H stack venting system	Vent stack with blowdown valves for emmergency depressurization	-45^{0}C	14.5MPA	Stainless Steel
Equipment				
Piping		-45^{0}C	14.5MPA	Seamless 316L stainless steel
Blowdown valve		-45^{0}C	14.5MPA	Forged 316L stainless steel, cryogenic specification
Control valve	Bi-directional control valve	-45degC	14.5MPA	Forged 316L stainless steel valve with cryogenic specification

3.34.3 Reasons for Materials of Construction

The circuit piping/and components are manufactured of 316L with cyrogenic capabilities to handle the low operating temperatures encountered during the depresurization of dense phase CO_2.

No CO_2 corrosion is expected under normal operating conditions. Upsets where water is introduced into the venting stack (condensation etc) are handled by the material selection.

3.34.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
General vent stack Piping	Mechanical Fatigue	It is prudent for operators and inspectors to be particularly sensitive to observations or reports of pressure or temperature fluctuation or piping vibration (during venting). Predictibility: GOOD
	Erosion	Erosion of the piping downstream of the throttling valve is possible and must be cotrolled through valve operating procedures Predictibility: GOOD
Valves		
	Erosion	Erosion of the valve trim in the trhottling and blow down valves is possible but is cotrolled through valve internals material selection (use of ENC) and operating procedures. Predictibility: GOOD

3.34.5 Inspection History – Highlights

None	

3.34.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)

3.34.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism
N/A	N/A	N/A

3.34.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.34.9 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
N/A		TBD

3.34.10 Recommendations and Material Changes

None

3.35 CC24903 – Pipeline Segment 4 from LBV 3 to LBV 4

3.35.1 Circuit Description

Pipeline from LSD 02-25-57-20 W4M to LSD 02-02-58-20 W4M with a length of kms (See Pipeline elevation profile in Appendix xxx) which includes the crossing of the North Saskatchewan River.

3.35.2 Equipment and Materials

CC24903	**Description**	**Normal Operating Conditions**		**Material**
		T (°C)	**P (MPag)**	
Pipeline	12NPS, WT: 14.3 mm	36°C	12 MPa	Low temperature carbon steel meeting minimum impact toughness of 60J at -45^{0}C with fracture apearance of 85%
Pipeline	crossing under the river	36°C	12 MPa	CSA Z245.1 Gr 386 Cat II with Triple layer Fusion bond epoxy external coating and cathodic protection
Equipment				

3.35.3 Reasons for Materials of Construction

The circuit piping is manufactured of CS to accommodate very low corrosion rates.

No CO_2 corrosion is expected under normal operating conditions. Upsets where water can be carried by the dense CO_2 and accumulate at low spots leading to aqueous CO2 corrosion is not possible due to the stringent control within the plant.

3.35.4 Damage Mechanisms

The failure modes for the respective corrosion mechanisms anticipated or experienced in this Circuit are described in the following table:

AREAS AFFECTED	DEGRADATION MECHANISM	NOTES
Pipeline and risers	External corrosion: Soil side corrosion	With time, the coating might become damaged and CP might not be adequate at some spots. Predictability: GOOD
	Internal (CO_2)Corrosion	Unlikely as no free water is expected. Predictability: GOOD
	Earth movement	Possible but managed with anchors and HDD design Predictability: GOOD

3.35.5 Inspection History – Highlights

None	

3.35.6 Special Inspection Considerations – Equipment (in addition to API 510)

Item	Location	Comments (e.g. how much, etc.)
LBV		Pressure tests as required by regulators

Special Inspection Considerations – Piping (in addition to API 570)

Item	Location	Comments (e.g. how much, etc.)
		River crossing inspections

3.35.7 Potentially Corrosive Injection and Mix Points

ID	Description/Purpose	Likely Mechanism

N/A	N/A	N/A

3.35.8 Startup and Shutdown Considerations

Equipment	Concern	Procedures and References

3.35.8 Potentially Corrosive Deadlegs

ID	Description/Purpose	Likely Mechanism
TBD		TBD

3.35.9 Recommendations and Material Changes

None