CALCULATION COVER SHEET

PROJECT	JOB NO.	BECHTEL CALC NO.	SHEET
KARSTO CO2 CAPTURE	25474	25474-000-M4C-CN-00001	1
		CLIENT CALC NO. 10112936-PB-P-TDO-0001	

SUBJECT	DISCIPLINE
KARSTO CO2 Capture Simulation -- Normal Case	PROCESS

CALCULATION STATUS DESIGNATION	PRELIMINARY	CONFIRMED	SUPERSEDED	VOIDED

COMPUTER PROGRAM / TYPE	SCP YES	SCP NO	MAIN-FRAME (NETWORK)	PC	PROGRAM NO.	VERSION / RELEASE NO.
					PROMAX	2.0

PURPOSE

To develop a simulation model of the Karsto CO2 Capture by MEA at normal case with reclaimer on/off.

DESCRIPTION

An overall model was developed for Karsto CO2 Capture plant.
Details of the model specifications and setup are described in this calculation.

HOLDS

ASSUMPTIONS

CONCLUSIONS

Heat and mass balance was generated based on the simulation output (Doc. No. 25474-000-M4-CN-00001 rev 1), Process Flow Diagrams (Doc. Nos. M5-BA-00001, M5-CN-00001 to 00005, M5-CY-00001, M5-QG-00001 & 00002 rev 1, M5-WP-00001 rev 0) are based on the simulation configuration. △1

REFERENCES

1 Design Basis, 10112936-0065-CTS, Rev.4
2 Bechtel simulation "*AmineSystem-62.pmx*", Dated 10/8/2007
3 Bechtel Engineering Design Guide for Sulfur Complex Overview, 3DG B40 001 Rev. 00
4 Bantrel Acid Gas Removal Systems Using Amines, B-12 Rev. 1.

						WLL App	App
				B.L.	DM		
1	REISSUED FOR INFORMATION	3	3	BL	DM		11/14/2008
0	ISSUED FOR INFORMATION	3	3	BL	DM		10/10/08
NO.	REASON FOR REVISION	TOTAL NO. OF SHEETS	LAST SHEET NO.	BY	CHECKED	APPROVED / ACCEPTED	DATE

RECORD OF REVISIONS

SUBJECT	CALC NO.
KARSTO CO2 Capture Simulation -- Normal Case	25474-000-M4C-CN-00001

KARSTO CO2 Capture

Karsto CO2 Capture Plant Simulation Model (Normal Case)

Simulation files 1

Normal_Reclaimer_On Nov11.pmx
Normal_Reclaimer_Off Nov11.pmx

Feeds input and initial estimates

1 Feed

a) The feed pressure is 1.8 mbarg per the Design Basis (10112936-0065-CTS, Rev.4)
b) The normal case is based upon 704 kg/s flue gas feed with temperature of 90 °C, per the Design Basis (10112936-0065-CTS, Rev.4);
c) Feed composition per normal case in the Design Basis (10112936-0065-CTS, Rev.4), SCR outage not considered.

2 Water Fog (X-101)

a) Water fog was modeled as two online mixers; 1
b) Water pressure set at 137 barg to water fog. Saturated flue gas temperature is 50 °C according to the dew point temperature of saturated flue gas (49.3 °C); 1
c) Differential pressure through booster blowers (K-101/102) set at 35 inch water (1.26 psi).

3 Amine Absorber and Water Wash (T-101/102)

a) Two identical absorber were modeled as a single tower. Two identical water wash sections were modeled as a single tower, separated from the absorber tower. 1
b) Absorber was modeled with 5 theoretical stages. Water wash section was modeled with 3 stages; 1
c) Absorber differential pressure set at 0.06 bar (0.8 psi). Water wash section is 0.02 bar (0.3 psi). 1
d) Flue gas feed enters at stage 5 of absorber, lean amine feed enters at stage 1 of absorber and semi-lean amine feed enters at stage 2 of absorber. The overhead vapour from absorber enters the bottom of water wash tower, make-up water enters the water wash tower at stage 1 and circulated water enters the water wash tower at stage 2. 1
e) Absorber and water wash section are both structured packed with Sulzer Mellapak 170X. 1
f) Absorber and water wash tower used TSWEET kinetics and VLE flash type. 1
g) MEA in lean amine feed specified as 35 wt%.
h) The outlet temperature of E-101 was set at 20 °C to ensure the emission of MEA and NH3 both below 5 ppm. 1
i) 20% of rich amine from the bottom of T-101/102 feeds back to the absorber as semi-lean amine after cooling.
j) Rich Amine load is 0.45 mole CO2/mole amine. Rich approach to equilibrium is 94% and lean approach is 14%. 1

4 Amine Stripper (T-103)

a) T-103 is modeled with 11 theoretical stages.
b) T-103 differential pressure set at 0.34 bar (5 psi).
c) Rich Amine enters at stage 2, flash gas enters at stage 4, vent steam and clean amine from reclaimer enters at the bottom of stripper.
d) T-103 are structured packed with Sulzer Mellapak 170X.
e) T-103 used TSWEET alternate stripper kinetics and VLE flash type.
f) Low pressure steam available at 2 barg and 270 °C per the Design Basis (10112936-0065-CTS, Rev.4) will be de-superheated to saturated steam at 135 °C. Low pressure steam is also generated using compressor waste heat.
g) Steam condensate was flashed and fed into the bottom of T-103 at 1.35 barg. 1

5 Reclaimer (X-102)

a) 0.7% of bottom from T-103 was taken to reclaimer X-102 for Reclaimer On case. 1
b) Mass exchange was simulated. Energy transfer was considered, assuming availability of 7 barg steam. Reclaimed MEA was vaporized and returned to the bottom section of the stripper, T-103. 1
c) No ion exchanged water was added.

SUBJECT	CALC NO.
KARSTO CO2 Capture Simulation -- Normal Case	25474-000-M4C-CN-00001

KARSTO CO2 Capture

Karsto CO2 Capture Plant Simulation Model (Normal Case)

6 CO2 Compressor (K-103A/B/C) and pump (P-108A/B)

a) After compressed to near critical point, it was cooled to 28 °C to liquefy and pumped by P-108A/B to battery limit pressure (200 barg). Promax shows the supercritical CO2 as Vapour.

b) CO2 dried after 2nd compressor stage to meet the reqirement on water contents (<50 wppm) per the Design Basis (10112936-0065-CTS, Rev.4). Drier regeneration not considered into flow scheme. 1

7 Heat Exchanger and Cooling Water 1

a) Approach temperatures for plate and frame exchangers is approximately 5 °C.
Pressure drop through plate exchangers set at 1.03 bar. Tube side of shell and tube exchangers = 0.69 bar
Shell side of shell and tube exchangers = 0.35 bar.

b) The sea cooling water temperature is 11 °C, per the Design Basis (10112936-0065-CTS, Rev.4). 10 °C rise was allowed.

8 Water Balance

a) The PFD depicts the design intent to recycle water within the CCC facility. In the PFD (WP-00001), streams 010, 323 & 415 are combined in TK-104, pumped up to water fog wia P-109 and to absorber via P-119, respectively. The mass difference between inlet and outlet of TK-104 is due to CO2 vent to atmosphere. 1

Conclusions:

a) CO2 recovery is 85.2 / 85.3% and the LP steam to CO2 ratio is 1.47 / 1.56 (lbs steam/ lbs CO2) with reclaimer on/off. 1

b) MEA in the sweet gas is 3 ppm and NH3 is 4 ppm, which is less than specification of 5 ppm. 1

c) Water contents in CO2 discharge is 45 ppm (wt).