CALCULATION COVER SHEET

PROJECT	JOB NO.	CALC NO.	SHEET
CO2 KARSTO	25474	Bechtel:25474-000-M4C-CN-00004 Owner:10112936-PB-P-TDO-0004	1
SUBJECT: Stripper sizing calculations		DISCIPLINE: Process	

CALCULATION STATUS	PRELIMINARY	CONFIRMED	SUPERSEDED	VOIDED	
	X				

	SCP		MAINFRAME PC		PROGRAM NO.	VERSION/ RELEASE NO.
	YES	NO	YES	NO		
COMPUTER PROGRAM/TYPE		X		X	Promax KG-TOWER Sulcol	2 3.2 1.05

Use of these calculations by persons, without access to pertinent factors and without proper regard for their purpose, could lead to erroneous conclusions. Should it become necessary to use any of these calculations in your work in the future, it is suggested that the calculations be reviewed with authorized Bechtel personnel to ensure that the purposes, assumptions, judgments and limitations are thoroughly understood. Bechtel cannot assume responsibility for the use of these calculations not under our direct control.

Reference Data: 1.

1) Bechtel Process Engineering Design Guide - Tower Internals
2) Bechtel Standard Drawing No. B-501,B505,B503,B-504
3) Bechtel Process Engineering Design Guide - Separators
4) Heat & Material Balance Normal Case

Design Basis: CO2 Kårstø - Exhibit E0 - Design Basis

Remarks:
This document provides the sizing calculation for Stripper.

Comments

RECORD OF REVISIONS

NO.	REASON FOR REVISION	TOTAL NO. OF SHEETS	LAST SHEET NO.	BY	CHECKED	APPROVED/ ACCEPTED	DATE
1	Issued For Information Including Comments P0046	7	7	MJC	HS/DM	ADB/BR	12-Nov-08
0	Issued For Deliverable Milestone Schedule M2	7	7	HS	MJC/DM	ADB/BR	08-Oct-08

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SUBJECT	Stripper sizing calculations			SHEET	2	OF	7 SHEETS

1. PURPOSE OF CALCULATION:

Sizing of the CO2 Stripper, MV-103 based on the design basis and bechtel standard guides

2. METHODOLOGY:

Heat and material balances developed for Normal reclaimer and without reclaimer operation by Bantrel were used in this calculation.
Column Diameter was calculated using two programs KG tower and Sulcol. Using conservative approach larger diameter was used to fix the diameter of the column.
These have been reviewed against the final Normal, Winter and Summer cases and where more conservative values have been taken from these cases. Turndown of 60% on design values is required and acheivable.
The height of the column was worked out based on:

Residence time of 5 mins for lean amine in column bottom (LLL - HLL).
Surge Volume provided for 5% of packing volume on draw-off tray.

3. COLUMN DIAMETER:

3.1 Software calculation

Basis of flows for diameter calculation

TRAY SECTION

	Flow kg/hr	Mol wt	Density kg/m3	Viscosity cp	Surface tension Dynes/cm		
Vapour	214663	28.4	1.8				
Liquid	8495	19.1	964.7	0.297	56.1		

PACKING SECTION

	Flow kg/hr	Mol wt	Density kg/m3	Viscosity cp	Surface tension Dynes/cm		
Vapour	205057	20.3	1.429				
Liquid	2292100	25.3	1074.6	0.506	47.1		

The results of the KG-Tower and Sulcol are tabulated below:

Packing Section

Program	Column Tag No.	Diameter mm	Internals	Flooding Limit %	System Factor	HETP Height m
KG Tower	MV-103	#	FLEXIPAK 250 YHC structure packing	0.8	0.85	2.0
Sulcol	MV-103	#	Mellapak 170X structure packing	0.8	0.85	2.0

Tray Section

Program	Column Tag No.	Diameter mm	Internals	Flooding Limit %	System Factor	Spacing mm
KG Tower	MV-103	#	Type-T,A-2	0.8	1.0	600.0
Sulcol	MV-103	#	MMVG	0.8	1.0	600.0

- values obtained from vendor software and subject to confidentiality agreement between Bechtel and vendor

Selected the largest column diameter 6665 mm say 6670 mm

3.1 Reboiler Configuration

The chimney drawoff tray collects all liquid from the packing above and directs it to the bottom of the reboiler sump where it is preferentially directed to the reboiler(s). Liquid from this sump flows through the reboilers by gravity and the two-phase reboiler outlet stream returns to the stripper. Reboiler vapor separates and flows up through the chimney tray into the packing. Excess liquid in the reboiler sump overflows the weir at the top of the reboiler sump and into the pumpout sump where it is pumped out as lean amine. This design is more stable in operation than a once-through reboiler configuration, and handles stripper turndown and/or variations in reboiler performance (fouling) very well. Mechanical details of the reboiler sump and the configuration of the reboiler return nozzles will be developed during detailed design after final vendor data is available on number and configuration of reboiler units.

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4. COLUMN HEIGHT:

4.1 Liquid Levels:

Flow Rate	2270918	kg/h
Density	1062	kg/m3
Volume Flow	2137	m3/h
Column Diameter	6.67	m
CSA	34.9	m2

The reboiler feed sump is assumed to occupy 17% of the column cross-sectional area, so 6 minutes sump provides 1min to reboiler and 5 mins to amine pump suction

	Calculated mm	Actual mm	Vol (m^3)	Hold up Vol (m^3)	Hold up min	
HHLL (from BTL)	8456	8500	295.5	35.6	1	1 min holdup time between HHLL and HLL
HLL (from BTL)	7437	7500	259.8	213.7	6	6 minutes required (see note above)
NLL (from BTL)	4378	4425	153.0	178.1		
LLL (from BTL)	1320	1350	46.1	35.6	1	1 min holdup time between LLLL and LLL
LLLL (from BTL)	300	300	10.5			

1

4.2 Liquid Levels on Draw-Off Tray:

The current internals configuration is for liquid to be collected in the reboiler sump at the bottom of the column. The following dimensions are calculated to provide sufficient column height for alternative reboiler configurations to be implemented later if desired.

Vapor Flow Rate	200088	kg/h
Density	1.3738	kg/m3
Volume Flow	145646	m3/h
Column Diameter	6.67	m
CSA Tower	34.9	m2
Chimney area= % of X-sec area	20%	(Bantrel B-501-SI, note 2)
Total X-sectional Chimney area	7.0	m2
Diameter of 1 chimney	3.0	m
Velocity through total chimney area	5.79	m/s
Limiting the chimney diameter to	1.0	m
CSA per chimney	0.785	m2
Clearance b/t plate and chimney to	0.250	m (9 Chimneys)
limit the gas velocity to 5.79		clearance= vapor exit area = chimney area (Bantrel B-501-SI, note 3)
Height above chimney	0.75	m min. 12" Bantrel B-504-IMP or 0.75 dr
Stream to reboiler	1441370	kg/h (Stream 318)
Density	1,067.8	kg/m3
Volume Flow	1350	m3/h

Chimney height = Buffer volume

5% of packed volume	34.94	m3
Total chimney height	1250	mm

Provide space for alternative reboiler arrangement with 2 draw-off nozzles from draw-off tray

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Min Depth of Pan

Based on 2 x N7 Nozzle size = 600NS 762 mm

Bechtel Standard 3DG-B10-017,page 68, 30" for 24" nozzle

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4.3 Column

Height		667	mm	> 305 mm or 10% D	Bantrel B-505-SI
		150	mm	Allowance for Demister	
Nozzle N2	50.8				
Manway 30"		762			
Liquid distributor					
From Distributor to Tray 1		600	mm		
Tray 1-3		1200	mm		
Nozzle N3	609.6				
Manway 30"	762				
From Tray3 to Bed 1		1500	mm		
Bed 1 height		4000	mm		
Nozzle N4	254				
Manway 30"	762				
From Bed 1 to Bed 2		1500	mm		
Bed 2 height		8000			
Bed 2 support	600				
From Bed 2 to Bed 3		1500			
Bed 3 height		8000	mm		
Bed 3 support		500	mm	Assumed	
Manway 30"	762			trayspacing +152 B-503-SI	
Bed 3 to N11		752			1
Nozzle N11 A/B		254			
Height above chimney		750	mm	min. 12" Bantrel B-504-IMP or 0.75 dr	
Clearance between plate and top		250	mm		
Height of chimney		1250			
Depth of Pan		762	mm	Pan not required for presented reboiler configuration	1
height above N6 to tray		854		trayspacing +152 B-503-SI + 102 margin	
Nozzle N5	254.00				
Nozzle N6		1219			
Nozzle N7	762				
Height above HHLL		610	mm	B-503-SI 305+305	
Height for level control		8500	mm		
Total height (T/T)		23580	mm		

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5.0 Column Tray Efficiencies:

	Theoretical Stages	HETP/ No of Trays per stage	Height m
Trays	1	3.00	1.2
Packed	10	2.00	20.0

Column Packing Section

Bed 1	4000	mm	Stage 2+3
Bed 2	8000	mm	Stage 4-7
Bed 3	8000	mm	Stage 8-11

6.0 Pressure Drops:

Pressure Drop through Packed beds	**1.65**	mbar/m
Tota Height of Packed Beds	**20**	m
Total Pressure drop	**33**	mbar
Pressure Drop through 1 tray	**5.1**	mbar

	Mass flow (Kg/hr)	Density (Kg/m3) Liquid	Gas	Velocity (m/s)	Pressure Drop	
outlet nozzle	214013		1.79	40.96	0.751	kPa
Top Trays drop	214013		1.79		1.530	kPa
Chimney Tray	0		0.00	5.79	0.000	kPa
Packed Bed	214013		1.79		3.300	kPa
liquid distributor	214013.00		1.79	0.95	0.003	kPa
ΔP					5.584	kPa

7.0 Nozzle Sizes.

N1:Vapor Outlet nozzle

Case	Normal Flow / No Margin			
Flow (Stream 320)	214013.0 KG/HR			
Density	1.79 KG/M^3			
Nozzle Diameter	40.00 IN	1016 mm		
No of nozzles	1.00			
Velocity	40.96 M/S			
	134.40 FT/S			50-150 ft/s
rv2	3003.7770 Pa			

N2: Reflux

Case	Normal Flow / No Margin			
Flow (Stream 322)	7321.2 KG/HR			
Density	988.48 KG/M^3			
Nozzle Diameter	2.00 IN	50.8 mm		
No of nozzles	1.00			
Velocity	1.02 M/S			
	3.33 FT/S			5-10 ft/s

N3 A/B: Rich Amine (Mixed Phase)

			WL	2189943.0
Case	Normal Flow / No Margin		Wg	37967.0
Flow (Stream 302)	2283100.0 KG/HR		rho L	1124.6
Density	98.10 KG/M^3		rho g	2.046
Nozzle Diameter	24.00 IN	609.6 mm	rho	108.6
No of nozzles	2.00			
Velocity	11.07 M/S			
	36.34 FT/S			25-45 ft/s
rv2	12032.5111 Pa			

N4:Flash Gas

Case	Normal Flow / No Margin			
Flow (Stream 312)	9550.1 KG/HR			
Density	2.12 KG/M^3			
Nozzle Diameter	10.00 IN	254 mm		1
No of nozzles	1.00			
Velocity	24.73 M/S			
	81.15 FT/S			50-150 ft/s
rv2	1294.9555 Pa			

N5: Amine from reclaimer

Case	Normal Flow / No Margin			
Flow (Stream 317A)	13850.0 KG/HR			
Density	1.66 KG/M^3			
Nozzle Diameter	10.00 IN	254 mm		1
No of nozzles	1.00			
Velocity	45.66 M/S			
	149.80 FT/S			50-150 ft/s

N6 A-D: Reboiler Return

Case	Normal Flow / No Margin			
Flow (Stream 314+319)	1441370.0 KG/HR			
Density	9.82 KG/M^3			
Nozzle Diameter	48.00 IN	1219.2 mm		
No of nozzles	4.00			
Velocity	8.73 M/S			
	28.65 FT/S			25-45 ft/s

N7: Reboiler inlet stream

Case	Normal Flow / No Margin			
Flow (Stream 318)	1441370.0 KG/HR			
Density	1067.80 KG/M^3			
Nozzle Diameter	30.00 IN	762 mm		
No of nozzles	1.00			
Velocity	0.82 M/S			
	2.70 FT/S			<4 ft/s

N8: To P-105A/B

Case	Normal Flow / No Margin			
Flow (Stream 314)	2270917.9 KG/HR			
Density	1062.47 KG/M^3			
Nozzle Diameter	36.00 IN	914.40 mm		
No of nozzles	1.00			
Velocity	0.90 M/S			
	2.97 FT/S			2-4 ft/s

N11 A/B:Vent Steam from flash tank

Case	Normal Flow / No Margin			
Flow (Stream 527, winter case)	5515.0 KG/HR			
Density	1.23 KG/M^3			1
Nozzle Diameter	10.00 IN	254 mm		
No of nozzles	2.00			
Velocity	12.29 M/S			
	40.32 FT/S			50-150 ft/s
rv2	185.7831 Pa			

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8.0 Sketch