Hydrogen Chloride Gas Scrubbing using Caustic Soda

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for HEE (Intel Fab Scrubbers DXI8133A, maximum flow, worst-case HCl loading)

Air Flow	95,000	acfm	Chlorides in Blowdown	3.8%	(as NaCl)
Inlet HCl Concentration	337	ppm_v	Bicarbonates in Blowdown	0.1%	(as $NaHCO_3$)
Inlet CO_2 Concentration	400	ppm_v	TDS in Blowdown	3.8%	
Liquid Recirculation Rate	1,323	gpm	HTU_{HCl}	0.70	ft
Blowdown Rate	15	gpm	NTU_{HCl}	5.71	
Temperature	70	°F	Outlet HCl Concentration	1.1	ppm_v
Atmospheric Pressure	29.92	in.Hg	HCl Removal Efficiency	99.7%	
Static Pressure	0.0	in.WC	Pressure Gradient	0.13	in.WC/ft
pH in Sump	9.0		Packing Pressure Drop	0.6	in.WC
Make-up NaOH Concn.	25%		Packing Volume	945	ft^3
Tower Diameter	15.5	ft (13.75 ft)²	Liquid Holdup	2.7%	
Packing Height	5.0	ft	Liquid Residence Time	9	sec
Safety Factor	1.25		NaOH Consumption	200	lb/h
Packing Type	Q-PAC			75	gal/h

Gas Flow Rate	95,000	scfm	Cross-Section Area	189	ft^2
=	245.57	lbmol/min	Gas Molecular Weight	29.0	lb/lbmol
HCl Removed	0.082485	lbmol/min	Gas Density	0.075	lb/ft^3
	37.448	mol/min	Liquid Density	8.34	lb/gal
	180.410	lb/h	Superficial Gas Velocity	502	ft/min
Blowdown	900	gal/h	Gas Loading	2,265	$lb/h\text{-}ft^2$
	56.78	L/min	Liquid Loading	3,503	$lb/h\text{-}ft^2$
$[Cl^-]$	0.7	mol/L	HTU_{CO2}	9.6	ft
$x_{1,CO2}$	3.18E-07	mol/mol	$[H^+]$	1.00E-09	mol/L
CO_2 Removed	0.4443	mol/min	T	294.3	K
$[CO_2]+[HCO_3^-]+[CO_3^=]$	7.83E-03	mol/L	P_T	1.00	atm
$[CO_2]$	1.77E-05	mol/L	K_w	7.16E-15	mol^2/L^2
$[HCO_3^-]$	7.48E-03	mol/L	CO_2 K_1	4.24E-07	mol/L
$[CO_3^=]$	3.24E-04	mol/L	CO_2 K_2	4.33E-11	mol/L
$[Na^+]$	6.68E-01	equiv/L			
NaCl	3.76%		**NTU calculation**	**HCl**	**CO_2**
$NaHCO_3$	0.06%		H (atm/mole fraction)	0	1,229
Na_2CO_3	0.00%		y_1 (ppm_v)	337	400
free NaOH	0.00%		y_2 (ppm_v)	1.1	396
Total Dissolved Solids	3.83%		Removal Efficiency	99.67%	1.0%
NaCl Saturation Index	-1.9		y_1^* (ppm_v)	0	391
$NaHCO_3$ Saturation Index	-2.3		y_2^* (ppm_v)	0	386
Na_2CO_3 Saturation Index	-5.7		$\ln(y_1-y_1^*)$	5.8	2.23
Sodium in Blowdown	1.92E+00	lb/min	$(y-y^*)_{lm}$ (ppm_v)	59	10
Make-up NaOH Density	1.274	g/mL	Expected NTU	5.71	0.42
Blowdown Density	1.02	g/mL	Calculated NTU	5.71 ✓	0.42 ✓
Caustic reacting with HCl	99%	of total	Discrepancy (×10³)	0.00000	0.00000
Alkali Exhaustion per Pass	48%				