The CONTACTOR™

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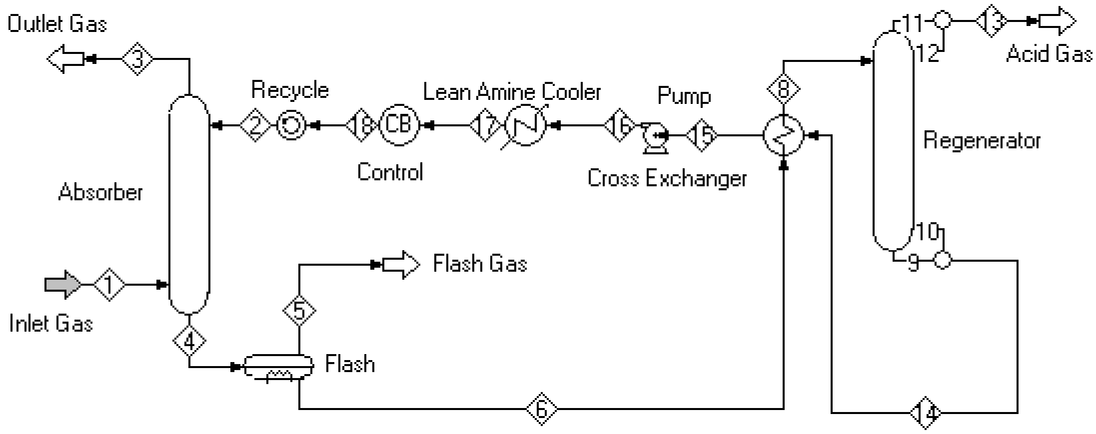
Predicting Future Performance and Identifying Process Limitations



Predicting plant future performance and identifying process limitations are critical in natural gas applications where flows and compositions are likely to change drastically as new wells are brought into production and treating requirements change. This is a case study of an offshore application demonstrating how simulations were used to design an amine plant to accommodate expected (and somewhat unexpected) deviations from the original process conditions (Table 1).

Table 1 Original Design Conditions

Inlet Gas Flow (MMscfd)	450
Inlet Gas Pressure (psia)	1076
Inlet Gas Temp (°F)	120
Gas Composition:	
CO_2 (mol%)	3.25
H_2S (mol%)	1.35
Treated Gas Specification:	< 1.0
CO_2 (mol%)	< 1
H_2S (ppmv)	< 4

Early in the project, the operating and engineering companies made some key design decisions, which included specifying the maximum circulation rate, the maximum reboiler duty, and the use of a 30-tray absorber, an unusually high tray count in a selective application. The plant was designed originally to use generic MDEA, and simulations confirmed that this solvent could easily meet treating requirements. This forms the design-case basis. It was then necessary to determine plant response to a variety of new operating conditions, treating goals, and constraints

With maximum rates established, INEOS Oxide was tasked with assessing likely plant performance under a range of other operating conditions. One of the main considerations was the possibility that the heat supply to the reboiler could become limited to about 57% of design at certain times. Under this circumstance, the plant was expected to operate at the reduced rate of 250 MMscfd. At this stage, the engineers recognized the advantages of implementing additional feed points to the absorber to control CO_2 slip. Table 2 shows the effect of varying the feed point on treat at both design and reduced flow rates. Feed nozzles were subsequently added to trays 24 and 19 of the absorber.

Just before the plant started up, the end user found that a much lower CO_2 level was needed in order to minimize corrosion in the down-

Table 2 Performance at Design and Reduced Rates from ProTreat Simulation

	Design Rate	Case 1	Case 2
Gas Flow (MMscfd)	450	250	250
Feed Tray from Top	30	**30**	**19**
MDEA (wt%)	50%	50%	50%
Circ. Rate (gpm)	2400	1500	1500
Treated Gas			
CO_2 (mol%)	0.92	0.59	0.99
H_2S (ppmv)	< 1	<1	< 1
Lean Loadings			
H_2S (mol/mol)	0.0002	0.0002	0.0002
CO_2 (mol/mol)	0.005	0.005	0.005
Rich Loadings			
H_2S (mol/mol)	0.13	0.11	0.11
CO_2 (mol/mol)	0.23	0.23	0.20
Reboiler Duty	**X**	**0.57 X**	**0.57 X**

stream pipeline. Therefore, instead of 1% CO_2, the plant would now have to meet a 1000 ppmv CO_2 specification. Clearly, the plant would not be able to meet this more stringent specification with generic MDEA. Since engineering and construction were already completed, the operator decided to proceed with MDEA to test the capabilities of the plant, and then eventually to upgrade to a specialty solvent to meet the 1000 ppmv CO_2 specification.

During startup, the plant experienced operational problems—higher than expected amounts of high-molecular-weight hydrocarbon in the feed caused severe foaming throughout the plant. Even with inlet gas separators and carbon filtration, the plant could not process more than 180 MMscfd and still remain below the 1% CO_2 product specification. Plant personnel observed that the hydrocarbon level increased with increasing number of trays in the absorber, indicating that longer residence time in the absorber increased the condensation of heavy hydrocarbons[†]. To maintain stable operation, plant operators fed the amine to tray 19, while minimizing the amount of circulating solution. Foaming also hindered the ability to strip the MDEA solvent adequately. Table 3 shows ProTreat simulations of two plant data sets. Unfortunately, reboiler duties were unknown so in the simulation, reboiler duty was adjusted to give lean H_2S loadings agreeing with measurements.

Despite the foaming, the ProTreat simulator predicts measured treated gas compositions with high accuracy. Note that in both plant trials, the measured H_2S loading exceeded 0.002 mol/mol and the H_2S exceeded 4 ppmv in the treated gas. To meet specifications, the solvent must be stripped to a lower H_2S loading than 0.002 mol/mol.

Table 3 Plant Trial Data Compared with ProTreat Simulations

	April	June
Inlet Gas (MMscfd)	180	170
Inlet Temp (^oF)	118	95
Inlet Gas Composition		
H_2S (mol%)	2.0	2.0
CO_2 (mol%)	2.2	3.25
Solvent		
Feed Tray (from Bottom)	19	19
MDEA (wt%)	56	48
Circulation Rate (gpm)	1040	1039
Treated Gas		
H_2S Measured (ppmv)	10	5
H_2S ProTreat Simulation	6	7
CO_2 Measured (mol%)	1.0 - 1.2	1.0 – 1.2
CO_2 ProTreat Simulation	0.9	1.2
Lean Solvent Loadings		
H_2S Measured (mol/mol)	0.0023	0.0026
H_2S ProTreat Simulation	0.0023	0.0027

After 5 months of operation with MDEA and little or no improvement in either foaming tendency or CO_2 treat, the operator decided to do a running conversion to GAS/SPEC* CS-2000* solvent. Because this solvent is much more reactive toward CO_2 than MDEA, the 1000 ppmv CO_2 specification was met with only 19 trays and at reduced circulation rate. An added benefit was that the higher rich loading reduced the solubility of the hydrocarbon in the amine and decreased the foaming. Two years later, the regenerator is stable and continues to meet specifications.—up to 450 MMscfd of gas are now treated within the design circulation rate and equipment parameters.

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[†] The ProTreat simulator accurately accounts for the effect of solvent type and strength, and acid gas loadings on hydrocarbon and BTEX solubility in amine treating solutions, but does not deal with a second, liquid-hydrocarbon phase.