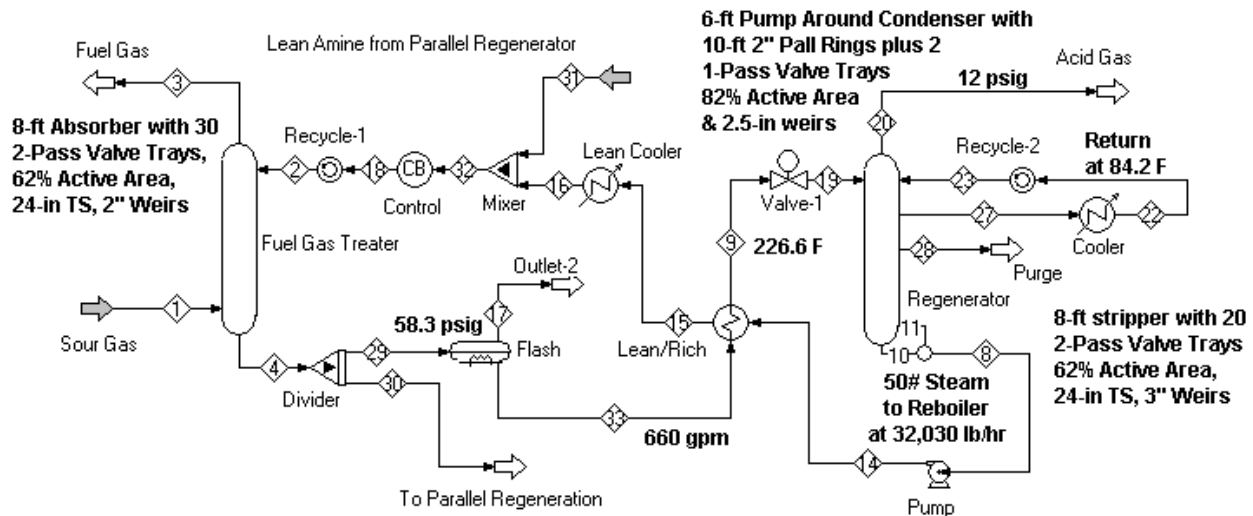


The CONTACTOR™

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HSS Contamination of a Refinery Fuel Gas Treater



This is the first in what we intend to be an ongoing series of quarterly technical notes, each one detailing with an interesting situation in gas treating. This first note^s deals with a refinery fuel-gas MDEA treater which was experiencing a steady decline in treating performance. Prior to February, 2005, the amine contactor was consistently treating H₂S down to levels of 1–3 ppmv in the vent gas. From February to May of 2005, the H₂S gradually increased to around 17 ppmv in the treated gas. Foaming was ruled out as a cause, and the lean/rich exchanger was shown to be leak free.

Over the February to May period, the lean solvent temperature climbed from 110 to 115°F and the lean H₂S loading rose from 0.0008 to 0.0046 mol/mol. However, the circulation rate increased from 770 to 850 USgpm. A number of explanations can be offered to explain the reduced performance:

1. Absorber was overloaded and was rich-amine-loading pinched,
2. Increased lean amine feed temperature caused a higher H₂S back pressure and lowered contactor performance,

3. Regenerator performance declined as indicated by the lean loading increase. This could have been caused by tray damage, exchanger fouling, lower reboiler heat input, or a change in heat stable salt (HSS) level.

The picture was complicated further by the results of initial material balance screening calculations around the absorber which showed a nominal 30% inconsistency between the measured rich amine loading, and the rich amine loading that would result from a material balance using the inlet gas composition and the metered feed gas and rich amine flows. In other words, simple material balances were inconsistent.

When the feed gas flow rate was assumed to be correct, the results from several simulation packages (including *ProTreat*™) all showed an H₂S leak 1,000 times too high. But when the feed gas flow as calculated by material balance (to give the observed rich solvent loading) was used for simulation, the following results were obtained:

Simulations Compared to May 2005 Plant Data

Parameter	May/05 Data	<i>ProTreat</i>	Other w/o HSS & Na
Absorber Tray No.	Tray Temperatures (°F)		
30 (Top)	115.3	115.1	115.0
25	115.4	115.3	115.3
20	116.5	115.6	115.6
11	117.2	116.6	116.4
7	121.2	117.9	117.9
3	142.7	135.4	134.2
1 (Bottom)	144.9	149.3	147.7
H ₂ S Leak (ppmv)	17	20	29
CO ₂ slip (%)	6.9–7.6	8.9	38.4
Lean Mole Loading	Lab		
H ₂ S	0.0046	0.0038	0.0132
CO ₂	0.0009	0.0000	0.0011
Total	0.0055	0.0038	0.0143
Rich Mole Loading	Lab		
H ₂ S	0.446	0.448	0.465
CO ₂	0.022	0.029	0.021
Total	0.468	0.477	0.486

Both simulators show close agreement with the measured absorber temperature profile, and at least order-of-magnitude agreement with the measured H₂S leak. It is noteworthy, however, that not only did the *ProTreat* simulator's use of the actual HSS and sodium contents give results in much closer agreement with the observed H₂S leak, but *the inclusion of HSSs and sodium ion appears to have been essential to reproducing the observed CO₂ slip*. But why did the treating performance deteriorate?

To answer this question, *ProTreat* simulation was used to do a sensitivity analysis. The following variables were changed in cumulative succession starting from the May, 2005 calibration model and working backwards in time to conditions corresponding to February, 2005 operations:

1. Lean amine temperature and to a lesser extent, feed gas temperature were lowered,
2. Amine strength was raised,
3. Regenerator reboiler steam was increased nominally by 10%, to the February value,
4. Heat stable salt and sodium ion concentrations were increased.

The lower amine temperature decreased the H₂S in the treated gas from 20 ppmv to 18 ppmv, a very marginal change. Raising the amine strength from 43.2 to 44.2 wt% actually increased the H₂S leak to

29 ppmv (probably the effect of higher viscosity on mass transfer). The higher February reboiler duty dropped the H₂S leak to 8 ppmv. However, only when the HSS level was increased from 5,945 ppmw to 7,690 ppmw did the H₂S leak drop to 3 ppmv, exactly what the fuel gas treater was observed to be producing during February. Further, *ProTreat* predicted 0.0005 H₂S lean mole load versus 0.0007–0.001 observed lean load. And the CO₂ slip was observed to be 6.9–7.6% in February, while *ProTreat* predicted 8.0% — the simulator without HSSs and sodium in the mix predicted over 40% slip!

ProTreat predicted very nearly the exact performance observed in February. The high HSS level in February, combined with a higher reboiler steam flow, is what allowed the plant to produce 3 ppmv H₂S gas. *The drop in HSS level hurt plant performance!* The simulation tool without HSSs and sodium chemistry capabilities missed both the reboiler steam benefit and the HSS effect. It also predicted a CO₂ slip some five times greater than observed. Satisfactory treating was re-established.

Lessons Learned

1. A simulation can only be as accurate as the data on which it is built and the precision of the simulation tool itself. *ProTreat*, being *truly rate-based*, was a superb tool for solving this problem.
2. In this particular case study, alternative material and energy balance verification had to be performed to develop a realistic picture of the problem itself and the data to be used.
3. Complete solution ion chemistry must be taken into account for accurate modeling of treating down to low H₂S levels at low lean loadings. *If the solvent is contaminated, the simulation must account for the contaminants.*
4. It is insufficient just to have an accurate contactor model. Rigorous *rate-based* regenerator simulation is absolutely critical to predict plant performance accurately. After all, contactor performance depends on lean quality, which is a function of regenerator performance.

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§ Case study taken from paper presented at Laurence Reid Gas Conditioning Conference, Norman, OK, Feb., 2006.