The CONTACTOR™

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Lean Loading: Simulate or Guesstimate and Does It Matter?

The February issue of The Contactor™ discussed how lean solvent H_2S loadings can be measured and reported with incredibly low values because in the presence of air, H_2S and HS^- ions will disappear by oxidizing to sulfite and thiosulfate. The current issue considers why it is important in simulation to use either *reliably* measured values of lean loading, or values determined by accurately simulating the actual regenerator.

Using figures derived from experience, rules of thumb, or we've-always-done-it-this-way approaches results in needless design uncertainty, and may lead to a suboptimal design or even a design failure. This will almost certainly not enhance prospects for winning a contract bid. There are several questions worth considering:

- How sensitive is treating to lean loading?
- How sensitive is lean loading to reboiler duty?
- What's the reboiler duty penalty for having to get a badly estimated lean loading to the right value for the job?
- If the estimated lean loading is wrong, how much reboiler duty margin do you have to allow and at what cost?

Case Study — a TGTU

The case study is based on a small refinery TGTU using 35 wt% MDEA solvent to treat 3.15 MMscfd of 15.4 psia gas having 13.8% CO_2 and 2.6% H_2S, balance nitrogen with trace CO and H_2. The absorber held a 30-ft bed of No. 1.5 Raschig Super-Rings®. The regenerator contained 24 standard valve trays with a kettle reboiler.

The plots in Figure 1 were generated by ProTreat® simulation of the standalone absorber using a matrix of lean solvent CO_2 mole loadings in the range 0.0001–0.01 and H_2S lean loadings in the range 0.001–0.01. Part of the design problem is understanding how TGTU absorbers operate and knowing how lean solvent loading (and temperature) affects treating. The other part of the problem is knowing how lean loadings are affected by reboiler performance, in particular the influence of reboiler duty.

TGTU absorbers are almost always lean end pinched with respect to H_2S and they slip the vast majority of the CO_2. H_2S pinching simply means that the treated gas H_2S content is more or less in equilibrium with the lean solvent, i.e., lean solvent temperature and loading control H_2S treat.

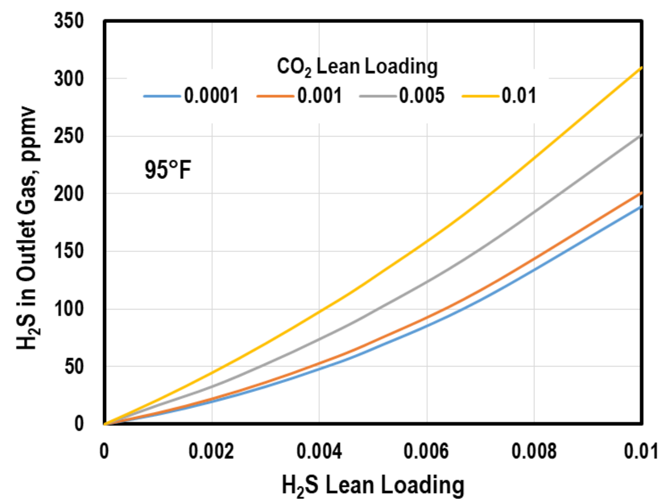

Figure 1 Treated Gas H_2S Depends on Solvent Loadings

In this particular case, 90% CO_2 slip was typical over a wide range of operating conditions, and with virtually all the H_2S being absorbed, the rich H_2S and CO_2 loadings going to the regenerator were known values at about 0.11 and 0.07 mol/mol, respectively.

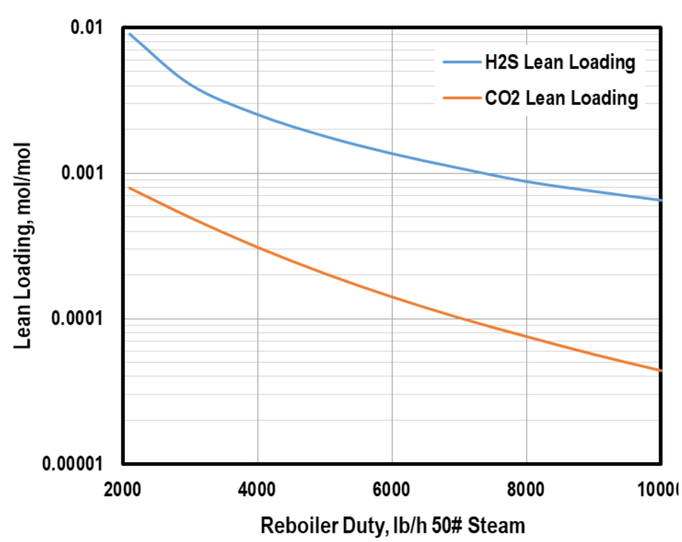

Figure 2 How Lean Loadings Depend on Reboiler Duty

As Figure 2 shows, roughly a one-for-one change in reboiler duty results in a similar change in lean loading; however, the response is certainly not linear. If you are working without benefit of ProTreat's highly accurate and reliable simulation capabilities, using estimated lean loadings (e.g., 0.005 for both acid gases) without a decent estimate of the reboiler duty needed to achieve these loadings will produce a suboptimal design. This is a small unit—in a large unit overestimating duty will provide a considerably more costly design. Underestimating duty results in a design that fails to meet the promised level of treating. The other unfortunate fact is that there is no safe and certain way to guesstimate the necessary lean loadings. The real issue is not the absorber; it's the ability of the simulator to predict regenerator performance. ProTreat® provides this predictive certainty.

Case Study — LNG Removal

It is well known that piperazine in MDEA-based solvents allows stringent purity to be met in a column of reasonable height without excessive reboiler energy consumption. The usual purity demanded is < 50 ppmv CO_2 in the treated gas. Piperazine is so reactive towards CO_2 that only very modest lean solvent loadings are needed to produce LNG quality gas. This means that regenerators often run fairly cold over most of their trays and packed height.

The absorber in this case study has 35 feet of No. 1.5 Raschig Super-Rings® and processes 325 MMscfd of methane containing 2% CO_2. It uses 2,000 USgpm of 35% MDEA promoted with 3 wt% piperazine in a completely conventional gas treating flowsheet.

Figure 3 shows how simulated treating performance responds to solvent lean loading and how lean loading of the regenerated solvent depends on reboiler duty. It is apparent that to reach a 50 ppmv CO_2 specification, the solvent must be regenerated to below 0.02 mol/mol lean loading. This will require a reboiler duty of just over 80 MMBtu/h. Above a duty of 85 MMBtu/h, further increases in duty yield little lean loading benefit. In other words, loadings below 0.01 can be achieved only with great expenditure of reboiler energy. Operationally, the excess internal steam traffic (which must be condensed again in the Condenser) needlessly ties up capacity.

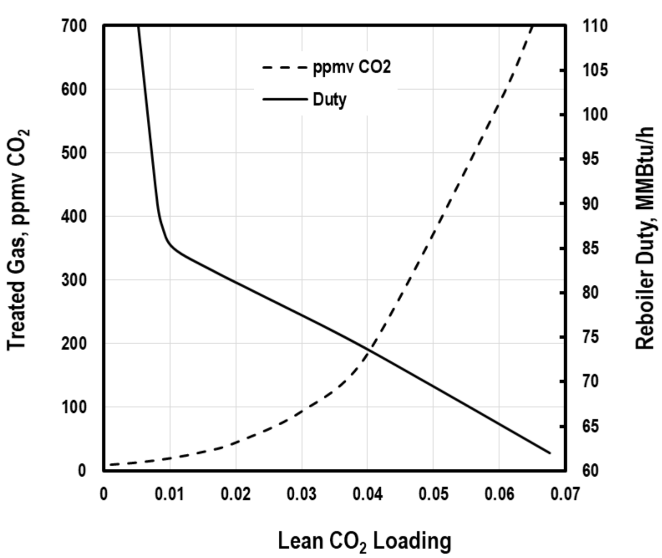

Figure 3 **Treating Level, Loading and Reboiler Duty**

The duty curve in Figure 3 shows a distinct break at about 85 MMBtu/h. At duties above this value, the absorber operates lean end pinched, and treating is controlled by lean loading. Below this inflection, the treating level is limited by solvent capacity and the vapor pressure over the rich solvent is very close to the column bottom pressure. This is very similar to the way CO_2 removal systems are operated in carbon capture applications.

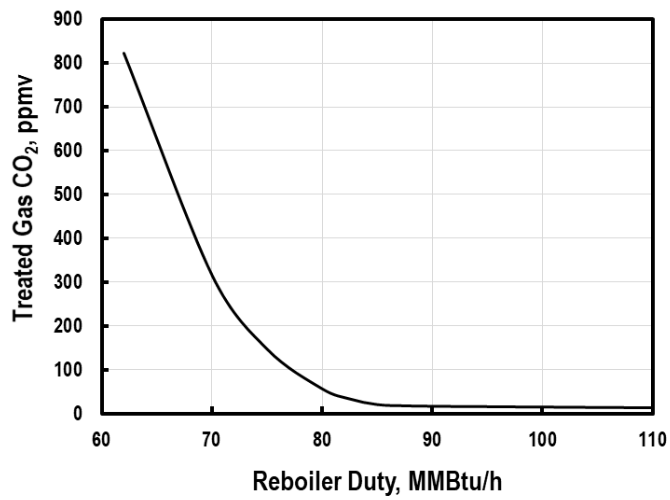

Figure 4 **Relationship of Treating Level to Reboiler Duty**

Figure 4 shows that treated gas CO_2 content responds only weakly to reboiler duty above 85 MMBtu/h, dropping from 20 to 13 ppmv at 110 MMBtu/h. This is a well-designed system because 50 ppmv is right at an easily-controlled point on the curve. But it would be foolhardy to base a design on an assumed lean loading. One might, for example assume a lean loading of 0.001 or 0.005 mol/mol which would require a much larger reboiler and end up producing gas that far exceeded the 50 ppmv specification. Such a design would be far from optimal and couldn't be considered very competitive in terms of either OPEX or CAPEX. The accuracy of ProTreat's regenerator model can help avoid such misfit designs.

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