



Amine Regenerator Feed Temperature: How Hot Is Hot Enough?

The rich solvent feeding an amine regenerator generally enters onto the feed tray below the bubble point at the conditions of the feed tray. While traveling down the column, the amine quickly heats up to temperatures close to the local dew point of the gas. This is achieved by extracting sensible heat from the vapor, but more importantly by condensing part of its water vapor content. Because the solvent feed is not yet hot enough, significant acid gas stripping will be delayed to a point lower in the column. In fact, sometimes the extent of feed solvent subcooling can be enough to cause some of the already stripped acid gas to be reabsorbed at, and immediately below, the feed point, undoing some of the work already done in the regenerator. This might suggest that a useful action might be to transfer more heat into the feed solvent and raise its temperature. A previous issue of *The Contactor* (Vol 11, No 6, *Where to Add Reboiler Energy*) discussed the consequences of too-cold rich-amine regenerator feed. The present issue discusses the effects of the feed being too hot.

Case Study

The case study is built around a unit selectively removing H₂S from a gas using 50 wt% MDEA. Our focus is on the regenerator which is stripping 285 USgpm of solvent loaded to 0.05 and 0.40 mol/mol with CO₂ and H₂S, respectively. The reboiler uses 17,000 lb/h of 50 psig saturated steam (15.5 MMBtu/h) for regeneration. The condenser operates at 120°F and 15 psig. So as not to contaminate the discussion with extraneous information, it is assumed that the condenser can handle any vapor flow rate presented to it; in other words, the physical size of the condenser is not limiting. At any feed temperature high enough for the vapor flow in the regenerator not to collapse the reboiler temperature was always about 261°F. Therefore, this is the maximum feed temperature achievable in any system relying solely on cross-exchange with hot lean regenerated solvent to heat the regenerator feed. Higher temperatures would require additional heating from an external source.

Figures 1–4 show how rich amine feed temperature affects the lean CO₂ and H₂S loadings, the percentage of the feed that is vaporized, and the condenser heat load for the conditions of this case. There are some interesting learnings from these plots, but first it should be recognized that the primary objective of the regenerator is to produce a lean solvent capable of allowing a low H₂S loading in the lean solvent to be achieved. CO₂ removal is not a goal, so low lean CO₂ loading is unimportant.

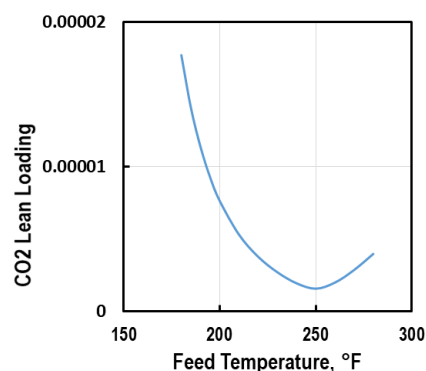


Figure 1 Feed Temperature and Lean Solvent CO₂ Loading

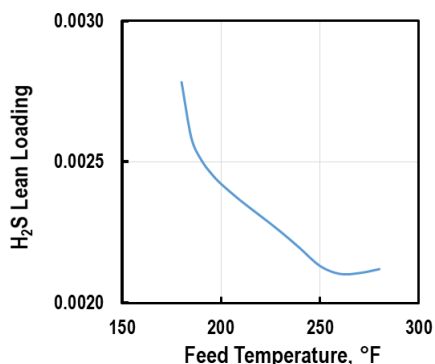


Figure 2 Feed Temperature and Lean Solvent H₂S Loading

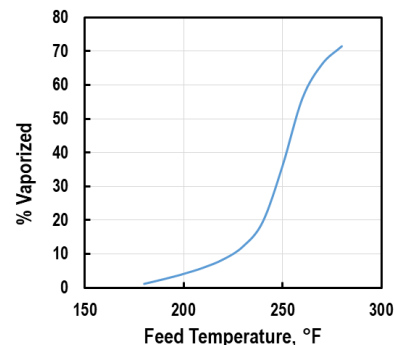


Figure 3 Feed Temperature and % of Feed Vaporized

Figure 1 shows CO₂ lean loading is fairly responsive to feed temperature; however, it has no effect on H₂S lean loading,

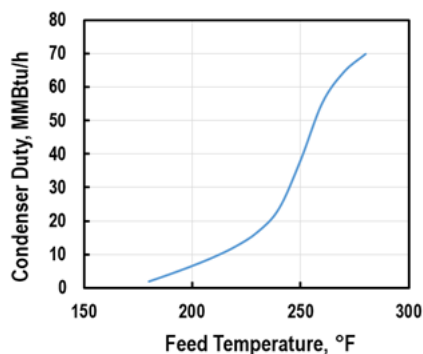


Figure 4 Feed Temperature and Condenser Heat Duty

so is irrelevant to this selective treating case. H_2S lean loading, on the other hand, hovers in the range 0.021 to 0.025 regardless of how hot the feed is made. Therefore, an extremely hot rich regenerator feed has only very marginal benefit in terms of the ability or ease of producing a specified H_2S level in the treated gas. Hot enough then is probably somewhere around 180°F in this case. Recognize, however, that the exact temperature depends on the reboiler steam flowrate. If the treating goal cannot be met under these circumstances, it probably makes most sense to put a little more energy into the reboiler in the form of a higher heating medium flow rate.

As Figure 3 shows, higher feed temperatures just mean larger feed fractions are vaporized, but the bulk of this material is condensed in the overhead condenser and returned to the column as reflux. In other words, the condenser is a trap that captures most of the vapor flow and returns it to the column. And, of course, condensing all this excess water and amine requires ever higher condenser duties (Figure 4) and ever larger condenser surface area. Worse, it's all for nothing. Thus, there are several serious consequences from overheating the regenerator feed. Included are:

- Increasingly rapid amine degradation,
- Unnecessary feed vaporization,
- Needlessly high condenser heat loads,
- High cooling water costs and/or very high condenser area and fin/fan power requirements,
- Grossly oversized condenser,
- Oversized cross-exchangers,
- Possibly poorly performing feed trays and/or liquid distributors because of a high flashing feed,
- Very high two-phase flow velocities in the feed piping which will almost certainly result in greatly increased corrosion rates from both the high wall shear stress and high velocity of any suspended particulates which will rapidly scour the metal and remove any iron sulfide protective film that might have been able to form,
- Deceptive values of the reflux ratio. For amine systems, reflux ratio is typically understood to be the ratio of the molar flow of water *returned to the column as reflux* to the total molar flow of acid gases plus inerts *in the stripper overhead*. This quantity is dependent not only on the boilup rate but also on the condenser performance *and on the degree of vaporization of the*

rich amine feed. Stripping Ratio (ratio of water to acid gases plus inerts in the column overhead stream) is a more precise specification but at very high vapor fractions it too loses much of its meaning.

For a stated reboiler duty, the temperature of the rich feed into the regenerator should be set at the minimum value needed to prevent the stripping steam flow from collapsing somewhere inside the regenerator. There are exceptions to this general guideline, typically in piperazine-promoted MDEA systems used for very low CO_2 specifications in the treated gas (e.g., LNG, ammonia, hydrogen, methanol plants), but going above this minimum value rarely proves sufficiently beneficial.

For the many reasons stated in this study, feed temperature to the regenerator is a very poor variable to use for controlling stripping. By far the better parameter is reboiler duty (hot oil or steam flow). To get an accurate handle on what feed conditions and what reboiler duty will provide optimal operating conditions, nothing beats the solid scientific basis of ProTreat® rate-based simulation.

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