

The CONTACTOR™

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Confident Design — Effect of Solvent Contamination

Previous issues of The Contactor have discussed the effect of solvent contamination by heat stable salts (HSSs) on treating unit performance. The types of unit considered have included tail gas treaters (atmospheric pressure), fuel gas treaters at moderate pressure and high pressure natural gas plants. The main finding was that HSSs can improve H₂S removal quite markedly *if the absorber is lean end pinched*, but they are detrimental to selectivity otherwise. This finding includes both the family of HSSs that are truly contaminants (organic acids, for example) as well as such mineral acids as phosphoric acid that are intentionally added for the specific purpose of improving selectivity by enhancing stripper column performance. In this issue of The Contactor we will consider contamination by surface active materials and liquid hydrocarbons that cause *foaming*.

Recently an EP&C company asked for advice on how to force the ProTreat simulator to match plant performance data. ProTreat software users might be aware that it is possible to adjust gas- and liquid-side mass transfer coefficients and active interfacial areas to vary performance predictions, but they may not be aware that the purpose of these adjustments is to enable data from a *poorly performing* tower to be matched. A properly operating tower requires no simulator adjustments of any kind for its data to be matched by the ProTreat model. Adjustability is intended for use as a troubleshooting tool. As more than one ProTreat user has told us, if the simulator doesn't match the operating performance data for a tower, there's either something wrong with the tower, or there's something wrong with the data. Indeed, if adjustments have to be made, ProTreat is no longer predictive—it's merely a best fit to the data, just like models that refer to equilibrium stages.

This particular case was a multi-train plant treating shale gas with generic MDEA in which the EP&C was engaged to revamp the plant for higher

throughput. The absorber and associated streams are shown in Figure 1. Volumetric flowrate of the lean amine stream was entered at meter-standard conditions, and the stream was then heated to the process temperature by the Heater.

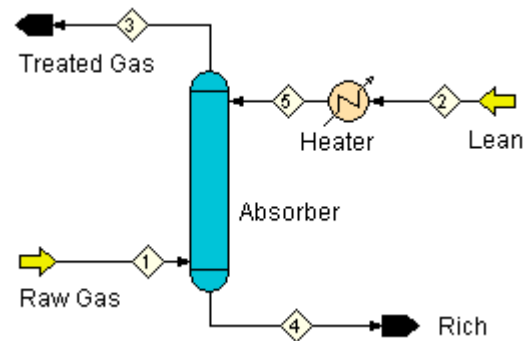


Figure 1 Shale Gas Absorber

A competitor simulation tool was reported to achieve a better match with measured CO₂ slip than what the ProTreat model predicted. ProTreat predicted higher slip rates (2.7% CO₂) than plant test data indicated (< 2% CO₂). There were two factors at play: (1) The other simulator was known to be over-optimistic when it came to estimating CO₂ absorption in MDEA, and (2) the solvent vendor's lab reported the solvent was a heavy foamer. A heavily foaming solvent is consistent with measured CO₂ slip values that were observed in the plant to vary over a wide range for no apparent reason.

Foaming is usually an intermittent event with two potential consequences: one is hydraulic, and the other is mass transfer related. Rapid fluctuations and sudden spikes in tower pressure drop (DP) are most often associated with foaming events because DP is what plant operators measure and see first. Serious foaming often makes a tower virtually inoperable and when it becomes that serious, pressure drop rises precipitously. However, *steady DP does not prove*

the system is not foaming—it may just mean the foaming is not hydraulically serious enough to have measurable effect on tower DP (which requires the foam to occupy all the space between the trays), or alternatively that the trays or packing are fouled. But surface active contamination may still have a significant effect on mass transfer by increasing the gas-liquid interfacial area. This can be especially the case if the tower is being operated well below its normal hydraulic capacity. A turned-down tower has plenty of otherwise empty volume between the trays to hold foam in the form of a biphase swollen from the increased frothiness that results from the incorporation of foam. Further-more, a foamy biphase tends to consist of a mass of smaller bubbles held within the matrix of the froth so a doubling of interfacial area, for example, does not require a doubling of the froth depth.

The question in the minds of the EP&C engineers naturally was how they could confidently guaranteeing a revamp that would produce on-specification gas at the promised increase in throughput. This was a particularly vexing problem, given that generic MDEA was going to be a marginal solvent for increased throughput in existing equipment in any case, and that the solvent was a bad foamer. Neither force-fitting equilibrium stages to the performance of a foaming system nor basing a revamp on an aggressive ideal stage model for CO₂ absorption were acceptable approaches. Instead, an authentic mass transfer rate-based model capable of accounting for foaming in a logical way was felt to be the safer approach because it was capable of (a) accounting for foaming in the existing system, and (b) actually predicting performance once the foaming problem had been resolved. The ProTreat mass transfer rate model also happened to be the technology used by the solvent vendor.

In passing, it may be worth pointing out that if the foaming problem was not resolved first, any increase in capacity, i.e., higher gas flow rate, would only exacerbate the foaming problem. The absorber would then stand a good chance of being beyond flood at the new conditions, despite being well below flood if the solvent was non-foaming. The other side of the coin however, is that although elimination of foam may eliminate flooding problems, *it may also result in worse mass transfer performance*. So is foaming always a bad thing? No, not always! As long as foaming can be controlled, it may actually enhance absorption rates by generating more surface area for contacting.

Table 1 shows the effect of increasing interfacial area on both the H₂S and CO₂ content of the treated gas. The effect on H₂S is rather slight. To match CO₂ removal data for the foaming system, the ProTreat simulator needed to use interfacial areas about 1.6 times the values corresponding to a clean solvent.

Table 1 Effect of Adjusting Area on Treating

Area Adjustment	CO ₂ (mol%)	H ₂ S (ppmv)
Unadjusted	2.28	1.73
X 1.5	1.87	1.63
X 2.0	1.53	1.55

The effect on H₂S removal is minimal because the H₂S treat is controlled by solvent lean loading at the column top. In other words, the column is lean-end pinched with respect to H₂S, so H₂S removal is controlled almost completely by phase equilibrium, not mass transfer. On the other hand, the effect on CO₂ removal is much greater. This is because CO₂ absorption rates are controlled by mass transfer resistance (in the liquid phase). *Interfacial area is a mass transfer parameter.*

These results point out the hazards of forcing ideal stage-based models (with or without reaction kinetics) to plant data. The plant in question was using a high foaming solvent so any model fitting was a fit to a poorly performing plant. Once the foaming problem has been addressed, however, there are no *low* foaming data to which the ideal stage model can be refitted, and from which one can extrapolate. The ProTreat simulator's genuine mass transfer rate-based model, on the other hand, properly accounts for the foaming, albeit by regression, but by regression of a meaningful physical characteristic of the trays in the column, namely the interfacial area. Furthermore, the adjustment of the parameter can be relaxed once the foaming problem is solved.

Perhaps the most useful piece of information from this is that although severe foaming can result in plant inoperability, moderate foaming *may* increase mass transfer (absorption) rates.

To learn more about this and other aspects of gas treating, plan to attend our workshop in Abu Dhabi or one of our free seminars in Houston, Denver, Calgary and elsewhere. For details, visit

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