

The CONTACTOR™

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Foaming and Mass Transfer Performance

Foaming is a ubiquitous problem in gas treating and it is certainly not clear that it always causes a reduction in performance. As in most things gas-treating, the answer is “it depends”.

Obviously, if the foaming is severe, performance will become degraded, possibly to the point where the column becomes inoperable. Severe foaming can block downcomers and prevent liquid down-flow. But more likely, the foam will grow to occupy the entire intra-tray volume and percolate out the top of the column. The entire column floods and the pressure drop becomes enormous. However, does high pressure drop always indicate foaming? No, certainly not. High pressure drop indicates *flooding*, not foaming, and flooding can be caused just as easily by an undersized column or a badly designed tray, i.e., by trying to operate a column with either too high a vapor or gas flow (jet flooding), or too high a liquid flow (causing downcomer choke flooding). On the other hand, a column can be foaming, but not enough to register unusually high pressure drop. If moderate foaming is known to occur, will it always harm operations, or are there circumstances where it will actually result in better treating? Is it system dependent? How will I know when to kill the foam and when simply to control it? The answers lie in understanding treating as a *mass transfer rate process*.

Foaming that still leaves a column hydraulically operable has two main effects: (1) it increases gas-liquid contact area for mass transfer, so tending to improve treating, and (2) depending on its nature, the foaming agent may create a stable semi-rigid film at the interface that prevents mixing and turbulence on the liquid side of the film, so tending to affect treating negatively. Foaming agents come in many forms, from a small amount of an insoluble hydrocarbon in an otherwise clean

system, to a high molecular weight surface active agent (including even an antifoam), to a layer of particulates at the gas-liquid interface, resulting from poor amine hygiene. Mass transfer rate-based simulation assumes a perfectly clean chemical system running in properly designed, installed, and operated equipment. If these criteria are met, a ProTreat® simulation should automatically match good performance data very closely. If it doesn't, the cause is going to be an incorrect piece of data, or an improperly operating column or other piece of equipment.

One of the common characteristics of foaming in an amine plant is unstable, randomly fluctuating operation, possibly caused by periodic foaming events that correct themselves by vomiting the foamer from a column when the rate of foam generation gets too high. The following example is taken from a shale gas operation in the northeastern corner of British Columbia. The absorber has 25 trays used to remove H₂S to below 4 ppmv from a gas containing 0.54 mol%. The other specification is to take the CO₂ content from greater than 10% down to below 2%. Feed gas pressure was 830 psia. An engineering contractor was engaged to investigate unexplained variations that were being seen in treated gas CO₂ content from 2% down to 0.5% (although the H₂S level was always well within specifications). Thus, the plant was meeting both specifications. But what are the most likely explanations for the unpredictable variation in treated gas CO₂ content?

Initial ProTreat simulations showed that under the actual operating conditions with the specific equipment in the plant, the gas ought to contain at least 2.25% CO₂, i.e., it should not have been meeting specifications. More than 35 trays should be required to reach the observed 1.8% CO₂ measurement. Instability suggests foaming as

a causative mechanism. However, foaming is generally thought to *reduce* performance, and this plant was showing better-than-simulated behavior. Hydraulically, the absorber was operating at only 67% of jet flood and 34% of choke flood so there was certainly room for a modest amount of foaming as long as the foam was not too stable.

The solvent appeared to be clean, as it was clear and of reasonable color. Thus, it seemed that if foaming was indeed occurring, it would tend to increase foaminess without coating the interface with a rigid film. Perhaps a small amount of liquid hydrocarbon was the culprit. Thus, higher surface area would be the likely result of foaming, with little or no impact on the mass transfer coefficients themselves¹.

Table 1 shows the effect on both H₂S and CO₂ treating of increasing interfacial area. It takes only a 25% increase in interfacial area to perfectly match normal performance. But a large area increase is needed to get to below 1% CO₂. Interestingly, surface area has no impact on H₂S treat, this being controlled by the loading of the lean amine (and its temperature).

Table 1 Effect of Interfacial Area on Treating

Area Relative to Non Foaming	H ₂ S in Gas (ppmv)	CO ₂ in Gas (mol%)
1.0	1.83	2.24
1.25	1.75	1.81
1.5	1.71	1.53
2.0	1.71	1.23
4.0	1.86	0.76
5.0	1.86	0.62

The gradually improving treating level can be explained by increasing foaminess of the gas-solvent mixture. Without further details, it is impossible to feel completely confident that foaming was indeed the cause. However, because the absorption process is mass transfer rate controlled (as far as CO₂ is concerned), one must look to causes connected to mass transfer. It might have been helpful to measure and record absorber pressure drop. However, if the column isn't foam filled and it remains hydraulically quite operable throughout the entire time, there is no reason to

¹ CO₂ absorption is completely liquid phase controlled, especially with MDEA (the solvent in this case). The absorption rate depends on $k_L a$. The k_L value drops when there is a rigid surfactant film, but the area, a , goes up with foaminess.

expect abnormally large pressure drop readings. However, it might have been useful to have temperatures on two or three trays in the column. This is supported by the temperature profiles that ProTreat simulations predict should exist under the various scenarios of Table 1.

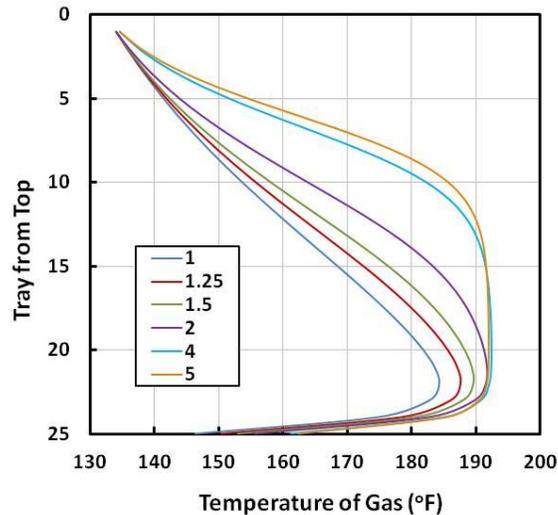


Figure 1 Absorber Temperature Profiles at Different Gas-Liquid Contact Areas

This plot gives evidence of the benefit to troubleshooting of installing thermocouples on even two or three trays in an absorber. In this case, even a single thermocouple on, say, Tray 15 from the top of the absorber could have revealed whether foaming is the real cause of the otherwise unexplained behavior. Convincing results are simply not possible with insufficient evidence. Of course, the other component is sound modeling using a tool such as ProTreat® simulation software, made truly reliable through modern science and engineering. Of coincidental interest are two additional observations backing up the ProTreat results. First, the solvent vendor had noted this system to be a “heavy foamer” repeatedly on solvent analyses. Secondly, the contractor had been asked as part of the study they were working on to find a way to reduce foaming.

To learn more about this and other aspects of gas treating, plan to attend one of our free seminars. Visit www.ogtrt.com/seminars for details on free one-day seminars scheduled for 2013.

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