The CONTACTOR™

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Dehydration Using TEG

Glycol dehydration is a process that presents some unique challenges from technical and computational standpoints. In the first place, modern designs almost invariably use tower internals consisting of structured packing rather than the more traditional bubble cap trays. Structured packing offers lower pressure drop and considerably higher capacity than trays. Structured packing is well suited to handling the very low L/G ratios common in dehydration. However, until now estimating height of packing used rules of thumb, not science. Mass transfer rate based modeling, on the other hand, uses science and therefore it offers greater reliability of design. The other challenge of dehydration using any glycol is thermodynamic.

The dehydration of streams having very high concentrations of acid gases is hard to model reliably because the thermodynamics of vapor-liquid phase equilibrium involves water, one of nature's most perversely-nonideal chemical species. Interactions between water and the acid gases CO_2 and H_2S, as well as with most hydrocarbons in the gas phase must be taken into account for a thermodynamic model to be reliable. Furthermore, in the liquid phase, aqueous glycol solutions themselves are quite nonideal because both water and glycol are polar molecules.

Optimized Gas Treating, Inc. has recently released a new glycol dehydration model, currently for TEG, and being extended to MEG and DEG. This note addresses the efficacy of the model in terms of (1) how well it reflects known phase behavior and (2) how closely it ***predicts*** known plant performance data using both bubble cap trays and packed columns *without recourse to HETP or HTU estimates and other rules of thumb*. This latest addition makes ProTreat™ the premier simulation tool not just for gas treating with single and mixed amines, but for acid gas removal with DMPEG and for dehydration.

Phase Equilibrium

The concern here is with the accurate calculation of equilibrium water content of high- and low-pressure gases containing very high levels of CO_2 and/or H_2S. ProTreat's dehydration model uses the Peng-Robinson equation of state (EOS) for the vapor phase and currently offers a 4-suffix Margules equation activity coefficient model based on the data of Bestani & Shing[†] for the liquid phase. A similar model based on the less conservative data of Parrish et al.[‡] is planned for a future release.

There are two important aspects to thermodynamic modeling: water content of the treated gas, and the hydrocarbon, acid gas, and especially the BTEX content of the water-laden glycol. Table 1 compares ProTreat model results with GPSA Data Book entries for saturated water content. Generally, ProTreat reproduces measured values of water content to within the accuracy of the data. The EOS

Table 1 Saturated Water Content of Gases

GPSA	Mole Percent (Dry Basis)			Temp	Pres	H_2O lb/MMscf	
Ref.	CH_4	CO_2	H_2S	(oF)	(psia)	Meas'd	ProTreat
Ex 20-1	100	0	0	150	1,000	220	216
Ex 20-2	80	20	0	160	2,000	172	188
Fig 20-9	0	100	0	100	500	132	125.3
					750	110	102.5
					1,000	125	100.7
					2,000	215	215.1
					3,000	238	247.8
	5.31	94.69	0	100	850	88	96.9
					1,125	81	99.2
					1,500	128	148.6
					2,000	139	184.2
Fig 20-16	89	11	0	100	2,000	40.6	41.1
	89	11	0	160	1,000	286	283.9
	80	20	0	100	2,000	40.6	45.1
	80	20	0	160	1,000	282	292.5
	80	20	0	160	2,000	172	188.5
	92	0	8	130	1,500	111	103.5
	72.5	0	27.5	160	1,367	247	252.6
	83	0	17	160	1,000	292	293.4
	30	60	10	100	1,100	81	81.2
	9	10	81	100	1,900	442	264.4
	5.31	94.69	0	77	1,500	109.2	95
	5.31	94.69	0	122	2,000	164.6	234.5

[†] See Clinton, Hubbard & Shah, LRGCC, Norman, OK, 2008
[‡] See Parrish et al., Proceedings 65th Annual Convention, GPA, 1986

(Peng-Robinson) that performs these saturated water calculations applies a large number of interaction parameters (k_{ij}'s) for the interactions between water and the various gases as well as between the gases themselves.

Other components whose solubility in TEG is pertinent are the acid gases and hydrocarbons, especially the BTEX components. Vapor-liquid equilibrium constants (K-values) for benzene, toluene, ethyl benzene and o-xylene are available in GPA RR-131and the data there have been used to fit the ProTreat solubility model for these species. The data indicate that at typical contactor conditions approximately 10–30% of the aromatics in the gas stream may be absorbed in the TEG solution. ProTreat results conform closely to the conclusions of RR-131 (as they should, because ProTreat's solubility model has been regressed to the actual measured BTEX solubilities).

Process Simulation

The GPSA Data Book contains a nice example of dehydration with TEG (Example 20-11). The gas is water saturated at 600 psia with other details noted in Figure 1. Two cases are detailed, both requiring two theoretical stages. One uses bubble cap trays which at a tray efficiency of 25 to 30%, translates into 6 to 8 actual trays. The other case uses 10-ft of an unspecified structured packing. ProTreat has provision for a separate

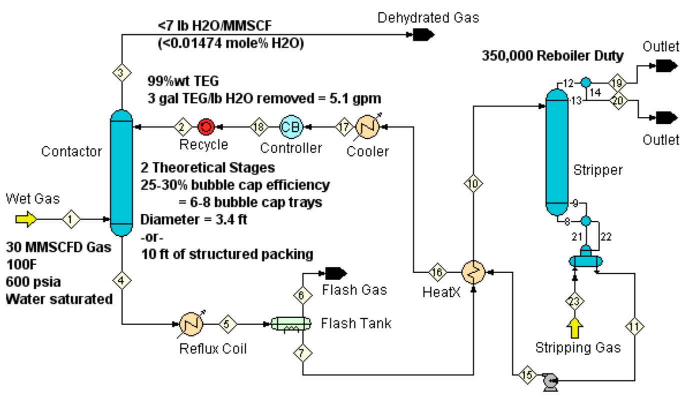

Figure 1 GPSA Data Book Example 20-11

Stahl column, shown immediately below the stripper in Figure 1 but the stripper can also be simulated without this column if desired. Two condenser outlet streams allow wet stripping gas withdrawal from the system (Stream 19), and removal of a specifiable portion of condensed water (Stream 20), with the remainder returned as reflux.

Table 2 shows the effect of the actual tray count on the water content of the dehydrated gas.

Table 2 Water Content vs. Tray Count

Number of Trays	Water lb/MMscf
5	8.5
6	6.7
7	5.7
8	5.1

ProTreat simulation indicates 6 trays are adequate to reduce the water content from 88.7 lb/MMscf to the target level of < 7 lb/MMscf. Tower diameter for 70% flood is 3'-0".

Table 3 shows that the crimp size of the structured packing does indeed make a difference and that packing with a finer crimp is needed to meet the dehydration goal with a 10-ft bed. It's not enough just to specify "structured packing" because performance depends on the *mass transfer* characteristics of the tower internals. The absorber diameter in this case is about 2'-3", consistent with the well-established fact that under otherwise identical conditions, columns with structured packing have higher hydraulic capacity than their trayed equivalent.

Table 3 Effect of Crimp Size

Packing Type	Water lb/MMscf
FLEXIPAC® 2Y	8.5
FLEXIPAC 1.6Y	6.5

The beauty of ProTreat's mass transfer rate based approach to simulation is that you never have to worry about tray efficiencies, artificial residence times, HETPs, HTUs, and other rules of thumb. ProTreat doesn't use rules of thumb—it uses science and good sound engineering to ***predict*** performance. These results were all obtained without any correction factors whatsoever. They are true predictions in every sense of the word.

To learn more about this and other aspects of gas treating, plan on attending one of our seminars. Visit www.ogtrt.com/seminars.cfm for details.