The CONTACTOR™

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Effect of Tower Internals on CO_2 Slip

In recent years, a lot has been written about what type of tower internals is best suited to high selectivity in gas treating. There seems not to be a definitive answer and, as it turns out, the correct answer is "it depends". In this issue of The Contactor we use a specific MDEA concentration to look at the effect of tower internals *type* on the ability to treat a specific gas stream and achieve the highest possible selectivity. It is obviously impossible to look at every conceivable tray design and packing brand and size, so this study is confined to 1-, 2-, and 4-pass trays, a single high performance random packing brand, and a single structured packing brand.

In no sense should the results presented here be construed as an endorsement of one internals type over another—the results are merely exemplary and they pertain only to the exact conditions used in the study. Other conditions will give different answers. The real purpose of this study is to point out that selecting internals is highly dependent on process details. Mass transfer rate-based simulation, specifically using ProTreat®, provides reliable answers that make sense.

Table 1 indicates the composition and conditions of the gas used in this example. The gas stream being treated is a fairly typical shale gas, in this case from a Canadian play. The gas already meets pipeline specifications on CO_2 but contains a nuisance amount of H_2S. Obviously, the absolute maximum in selectivity is desired.

Table 1 Gas Conditions and Composition

Temperature (°C)	31.8
Pressure (kPag)	3100
Flow (MMscfd)	90
Composition	
CO_2 (mol%)	1.1
$H2_S$ (ppmv)	26
Methane (mol%)	98.8974

To keep things as simple as possible, the same 40 wt% generic MDEA solvent flowed at the same 535 L/min for all simulations, and the regenerator configuration and conditions were kept constant. Twelve trays on 30-inch spacing were used and all packed beds were 30-ft deep so the same absorber shell was used in every case.

Before dealing with CO_2 slip, it should be stated that all cases simulated produced a gas that easily met the < 4 ppmv H_2S specification. In fact, the treated gas H_2S level was always well below 1 ppmv. Table 2 compares the 1- and 2-pass trays (conventional valve type with 1.5-inch weirs to minimize CO_2 pickup) with several sizes of random and structured packing.

Table 2 CO_2 Slip Using Trays and Packing

Internals	CO_2 Slip (%)
1-Pass Trays	75.0
2-Pass Trays	86.1
1.0-inch Random Packing	74.3
1.5-inch Random Packing	77.3
2.0-inch Random Packing	78.5
Structured (35-mm crimp)	76.4
Structured (20-mm crimp)	69.2
Structured (16-mm crimp)	66.0
Plant Data (1-Pass Trays)	75

The first thing to notice is that the ProTreat® simulated slip and the plant test data are identical. This result was *not* obtained by adjusting or tuning any parameters to force agreement. The comparison is between a *measured* value and a value obtained by *out-of-the-box prediction*. So it is a good indication of ProTreat's ability actually to predict performance

The highest slip is obtained when 2-pass trays are used. Until recently, to maximize CO_2 slip the standard generic recommendation was to use packing and it can be seen from the results shown in Table 2 that large size random packing (2") and large crimp structured packing both slip a little more CO_2 than a 1-pass tray. Under other sets of flow conditions, the differences between these three internals could be quite different, but it's probably going to be generally true that large packings will surpass trays under normal operating conditions. This is exemplified by Table 3.

The results in Table 3 correspond to 150 MMscfd feed gas with 3% CO_2 and 1,000 ppmv H_2S being treated with 1,500 L/min of 30% MDEA.

Table 3 Absorber with 1500 L/min 30% MDEA

Internals	CO_2 Slip (%)	H_2S Leak (ppmv)
1-Pass Trays	50.8	2.9
2-Pass Trays	60.4	1.8
4-Pass Trays	64.3	1.6
1.0-inch Random	53.1	6.3
1.5-inch Random	54.4	6.7
2.0-inch Random	54.7	9.8
Structured (35-mm crimp)	67.5	7.0
Structured (20-mm crimp)	60.4	6.4
Structured (16-mm crimp)	58.0	6.6

With 1-pass trays, the absorber shows 51% CO_2 slip, which is lower than any of the packings trialed. In this instance, structured packings give superior CO_2 slip to the random packings while performing at about an equal level in terms of H_2S leak. However, none of the packings have as low an H_2S leak as the 1-pass tray, and multipass trays are better still. They also provide superior CO_2 slip.

Under the flow conditions of this example, the 1-pass tray has a fully-liquid-loaded weir and is operating in the froth regime. The 2-pass and 4-pass trays, however have weir liquid loads of only 56 and 35 gpm per foot of weir length, respectively. Both of these trays are operating with the solvent in the form of a spray which, as discussed by Weiland and Hatcher (*Hydrocarbon Processing*, January, 2012), results in better H_2S removal and increased CO_2 rejection.

To the question, "What tower internals should I use to maximize CO2 slip?" the answer really is, "It depends". It depends on the composition of the gas being treated and the solvent strength and flow rate needed to remove the desired amount of the acid gases. Depending on the specific conditions, a 1-pass tray may already be operating in the spray regime, in which case pushing the tray deeper into that operating region may not have as large an effect as hoped. On the other hand, the L/G ratio may be so high it just isn't possible to use the number of tray passes as a way to force spray regime operation and enhance CO_2 slip. In such cases, packing may offer decided advantages to increase slip. But whatever approach one might suggest, ProTreat® mass transfer rate-based simulation will provide unequivocal answers as to the efficacy of the suggestion.

The advantage of ProTreat is that its mass transfer rate-approach to simulation (1) uses mass transfer characteristics and hydraulic parameters directly connect to the specific internal being considered, (2) ties those characteristics and parameters to the specific operating conditions on each tray or packed segment, and (3) uses the physical *and transport* properties of the real phases being contacted with each other. This is all done with absolutely no guessing, no estimating, no setting of artificial parameters, and no need for prior knowledge as to how a similar unit behaves—just solid simulation based on the sound principles of engineering science. The result is simulation results you can count on for accuracy and the ultimate in reliability.

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