GPA Canada, 6 Nov 2014

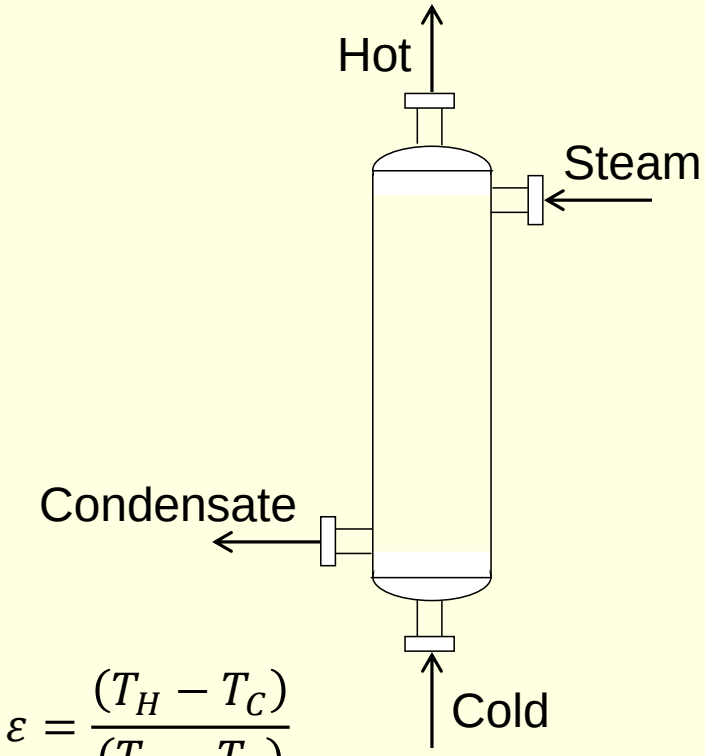
CO_2 Absorbers in LNG Production: Some Design Pitfalls

Nathan A. Hatcher[1], Clayton E. Jones[1], R. Scott Alvis[2] & Ralph H. Weiland[3],
Optimized Gas Treating, Inc.
[1] Technical Development Centre, Buda, TX
[2] 12337 Jones Rd, Suite 432, Houston, TX 770170
[3] Route 5, Box 940, Coalgate, OK 74538

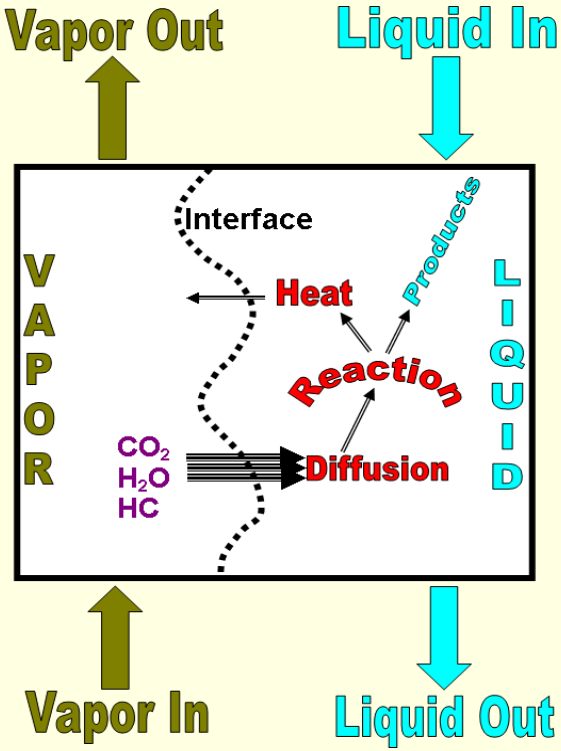
Piperazine-Promoted MDEA

- LNG, Ammonia, Hydrogen, Syngas
- All Deep CO_2 Removal
- Why piperazine?
- ProTreat® Simulation
  - Basis: Mass transfer rates
  - Not ideal stages, Not efficiencies
- LNG Flowsheets: Split flow configurations
  - Why & How
    - Swaged Absorbers
    - Separate Absorbers

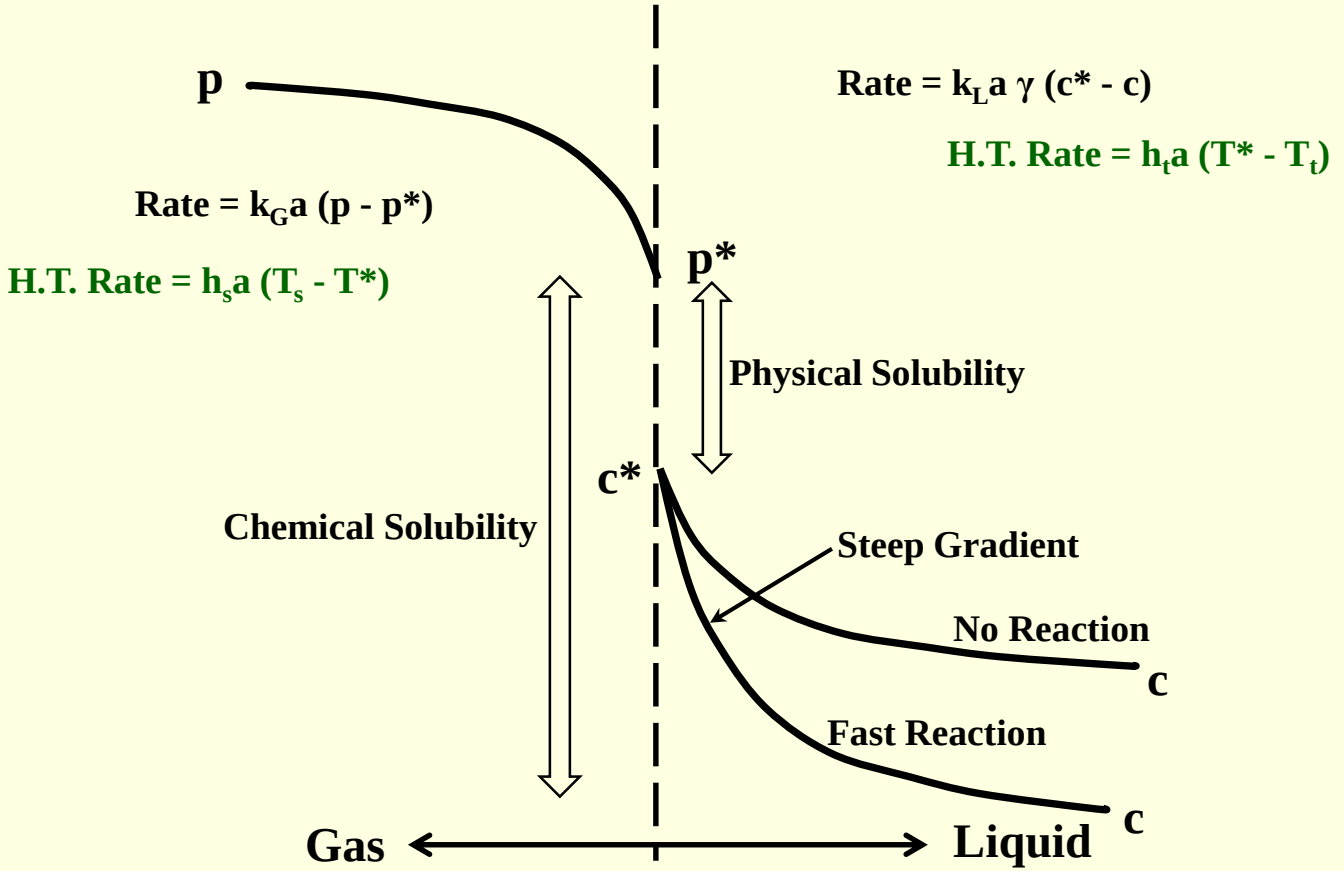
Simulation Basis



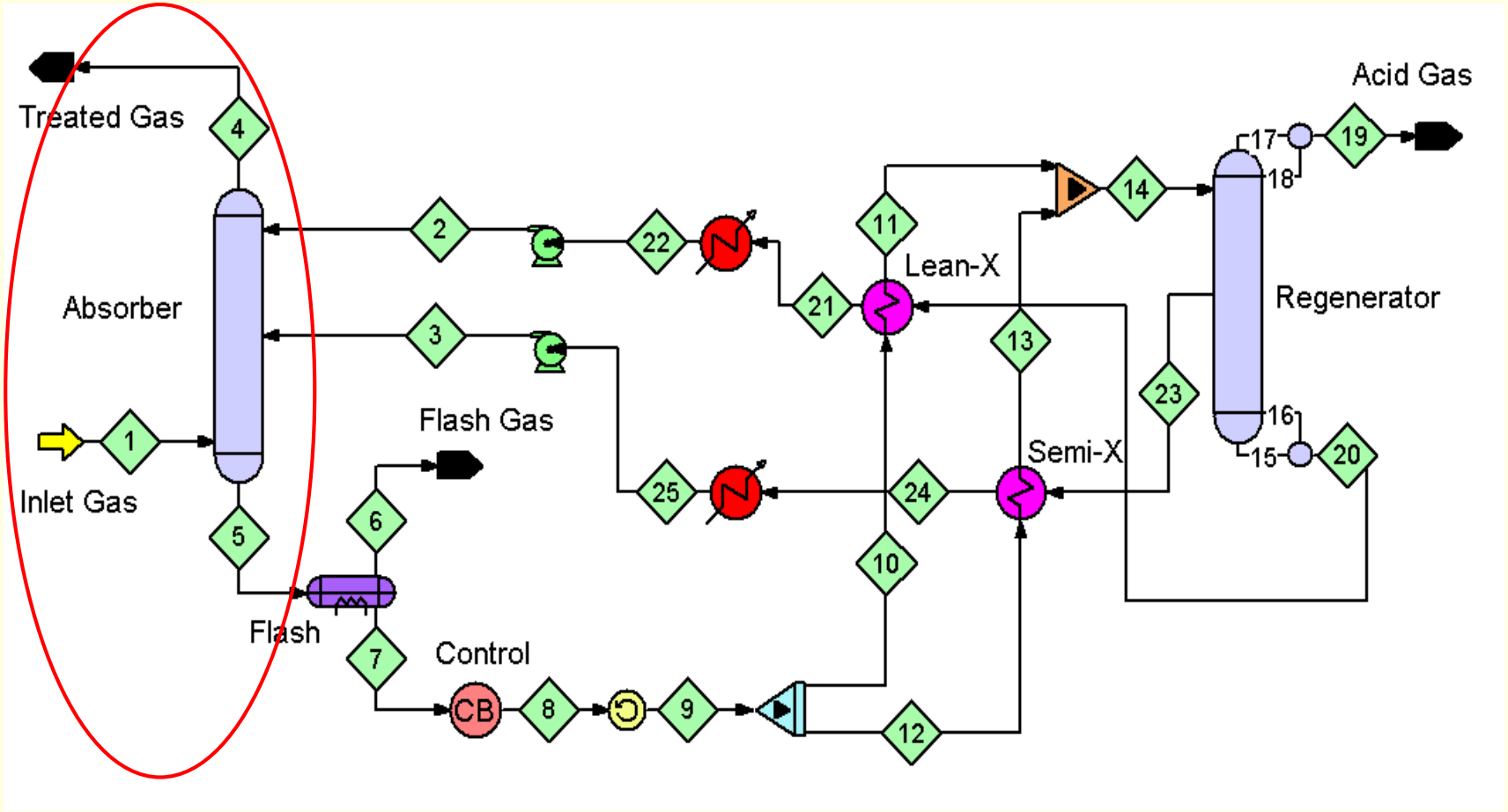
$$\varepsilon = \frac{(T_H - T_C)}{(T_S - T_C)}$$



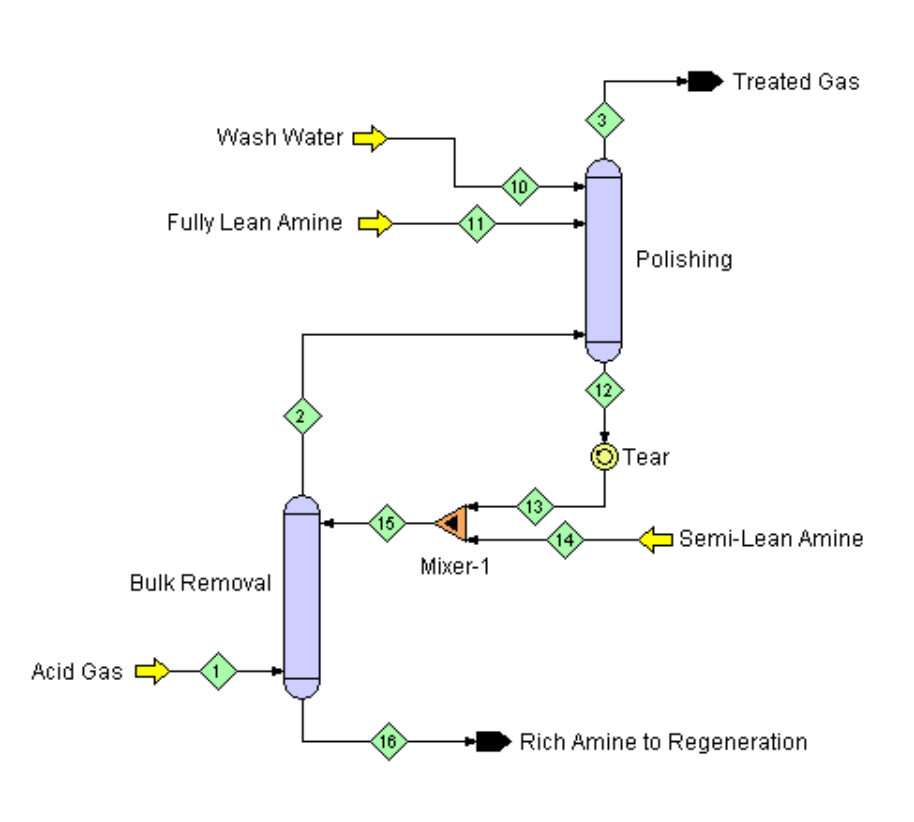
Simulation Basis



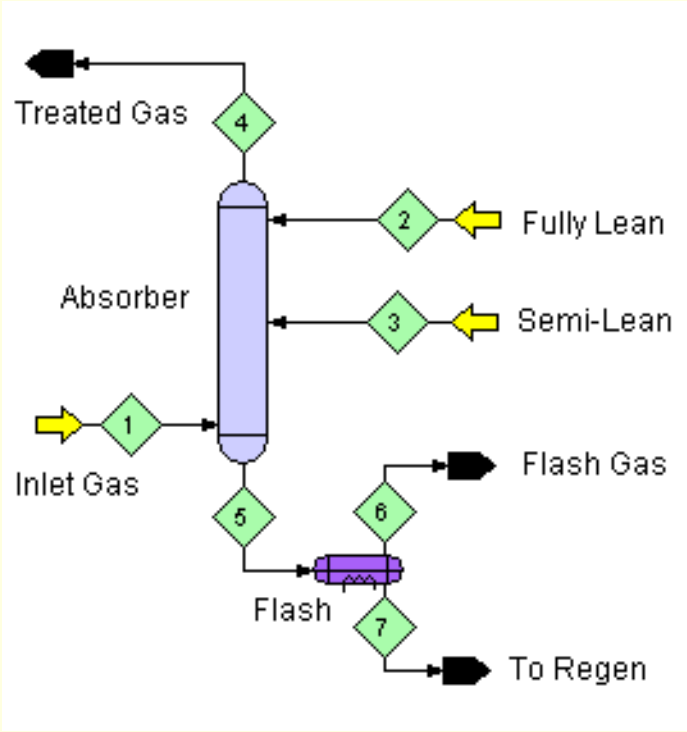
Split Flow Processing



Split Flow Absorbers
2 Configurations

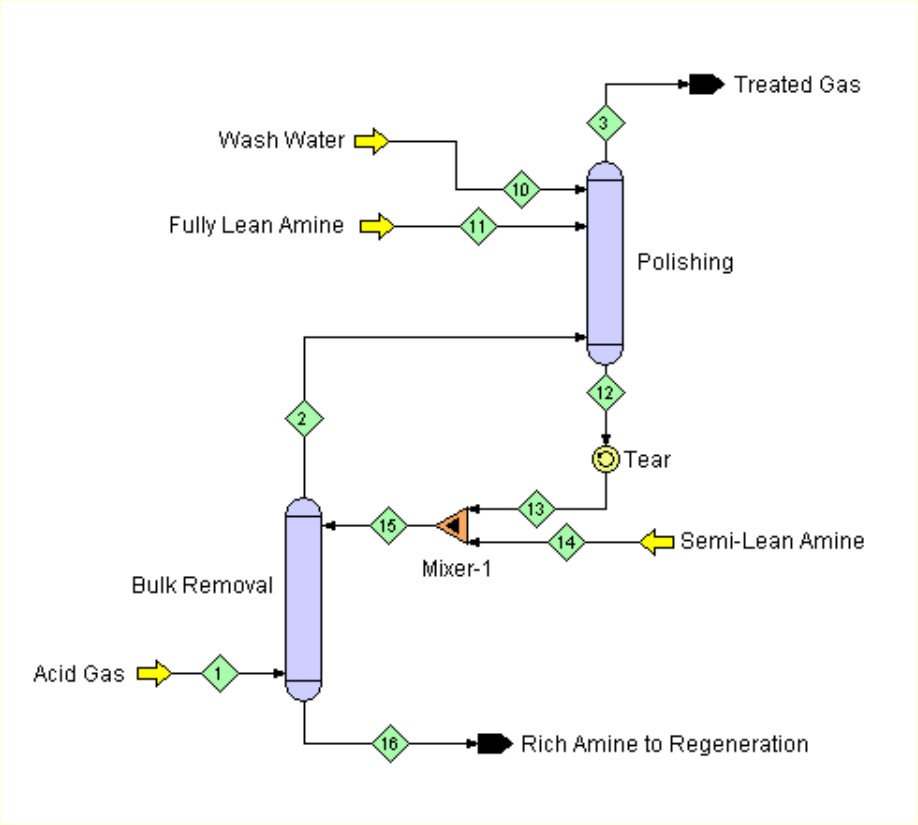


Case 1



Case 2

Case 1

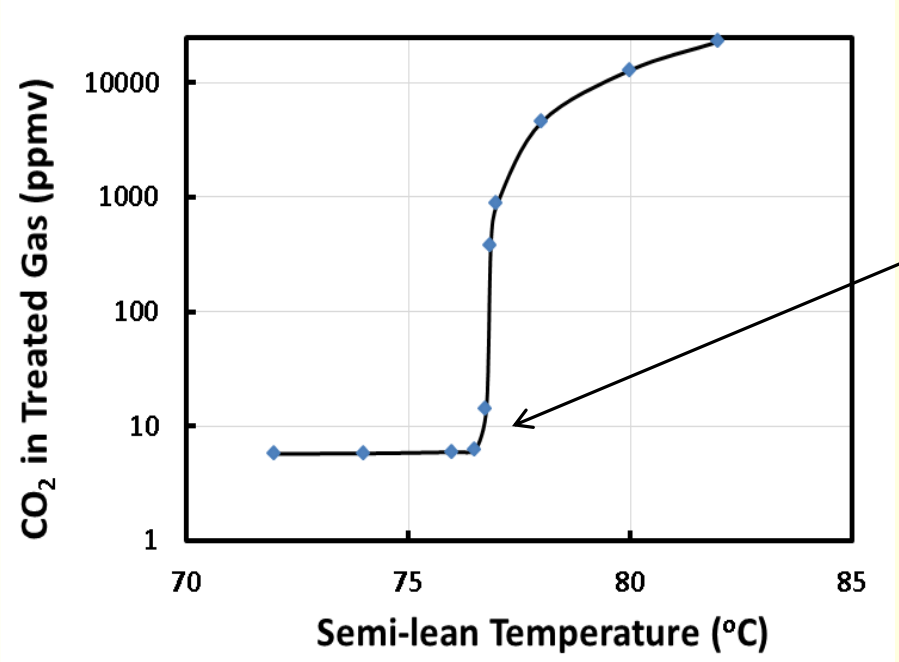


- Polishing Column has Two 5.5 metre beds Rauschert Hiflow Metal Rings

- 45 barg
- Fully Lean 48°C, 770,000 kg/h
- Semi Lean 4,480,000 kg/h
- 17.5% CO_2
- 37% MDEA + 3% piperazine
- Licensor recommended semi-lean temp. 70°C maximum
- Couldn't meet specifications
- 1,000s ppm CO_2 at design rate

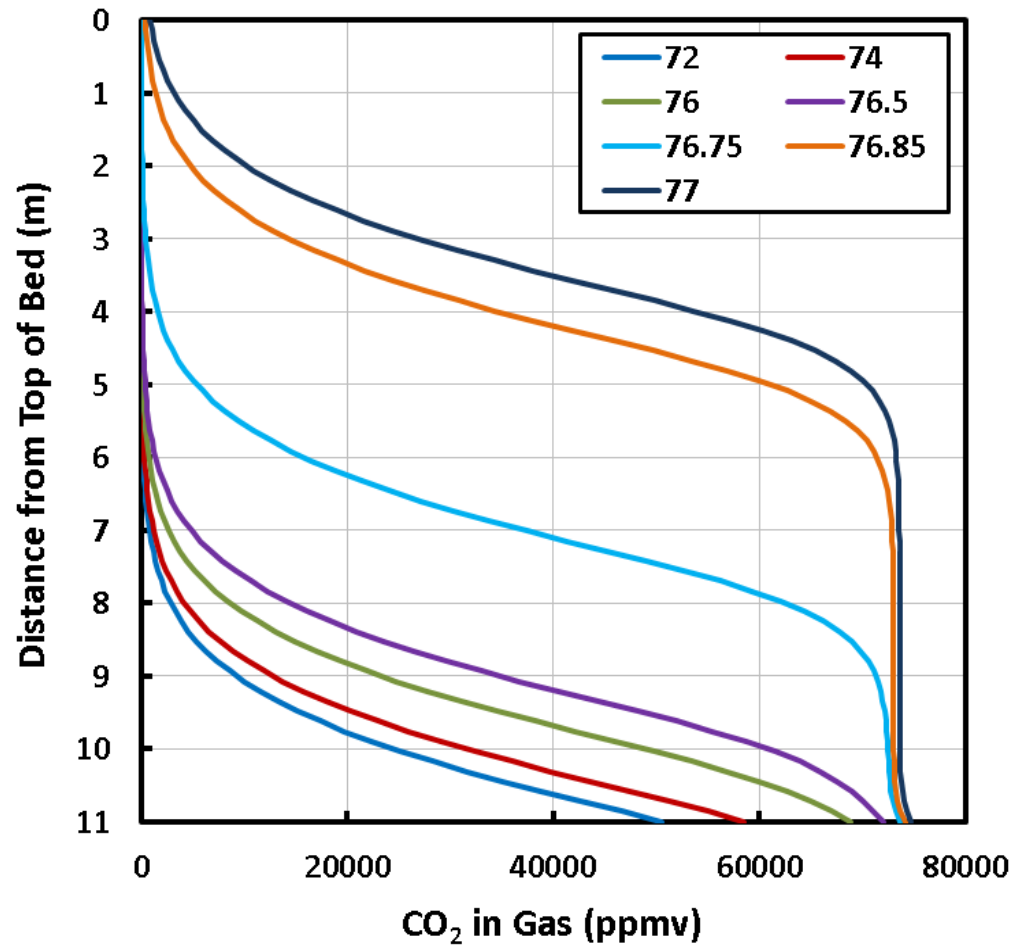
Case 1 cont'd

- Who got blamed? Internals vendor 1st of course ☺
- **Undersized semi-lean amine cooler**
- Semi-lean temperature --- **80°C** !!!
- ProTreat® Simulation →



- Semi-lean too hot
- Capacity lower
- Bulk removal saturated
- CO_2 starts to break through
- Polishing can't handle load

Bulge Pinch Strikes Again

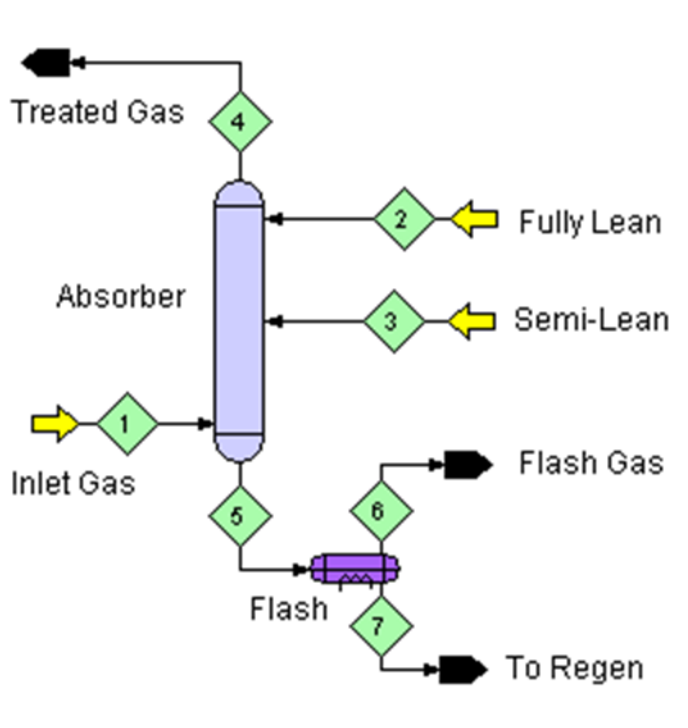


Bulge Pinch Strikes Again

- On the cusp, a bulge pinch may expand explosively
- No warning!!!
- Conclusions:

1. Bulge pinches may be associated with unstable operating region. The Cure: recognise and stay away from instabilities
2. If a small change in a variable causes a wild change in a simulated performance parameter your simulator may not have gone crazy — it may be telling you something important, so…
3. Don't call tech support — pay attention and study the problem.

Case 2



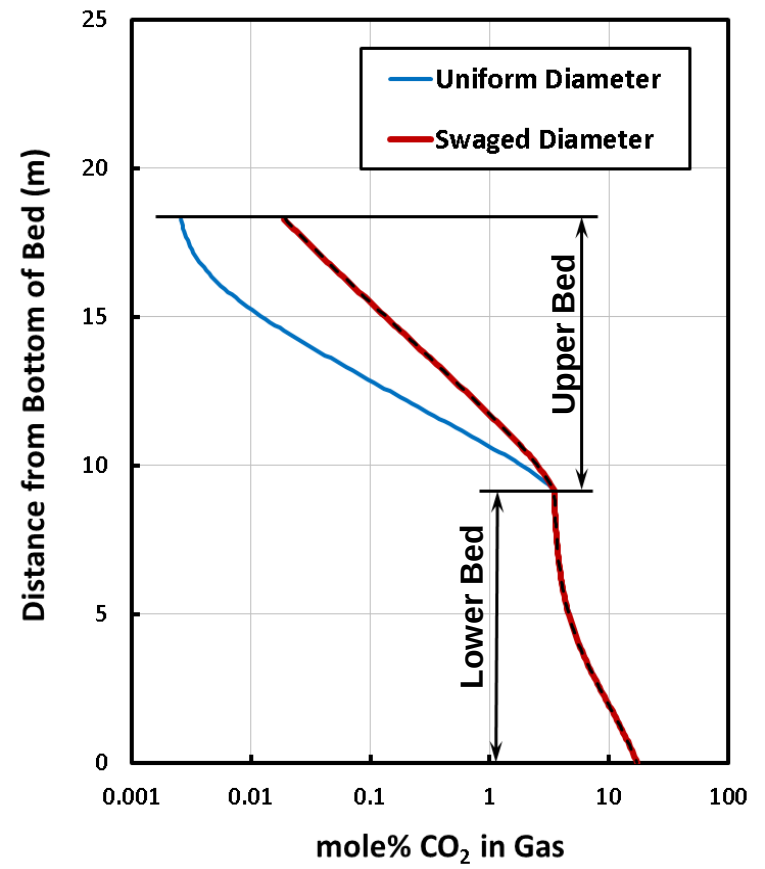
- 45 wt% Specialty Amine
- 17.5% CO_2 w/ C1, C2
- Gas at 31 barg
- 9.1-m Upper & Lower beds
- Raschig
  Super-Rings® No. 2

- Fully lean at 450 m^3/h
- Semi lean at 2725 m^3/h
- Engineering study
- Swage Absorber?

Case 2 cont'd

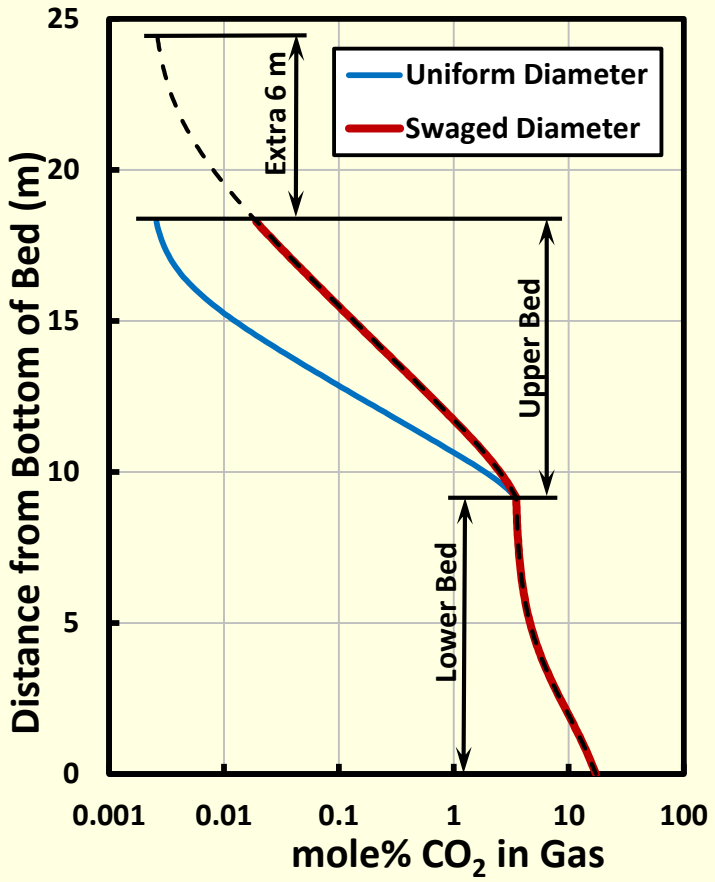
- Uniform diameter:
  - 4.5 m → 25.8 ppmv CO_2
  - Diameter set by lower bulk-removal section
  - Swage to smaller diameter upper section?
- Simulated for 80% flood in each section
  - Upper section → 2.6-m diameter!
  - Shell savings and smaller packed volume too (48 m^3 vs. 145 m^3)
- **BUT** simulated treating only 200 ppmv CO_2

Case 2 cont'd



- Need a deeper bed
- Think mass transfer, not HTUs and HETPs
- What's changed?
- Mostly, total wetted area in upper bed
- Only 4,400 m^2 vs. 12,000 m^2 for mass transfer
- Height less important
- **WETTED AREA MATTERS**
- Coefficients change too so…
- Cannot linearly scale on area
- Must simulate

Case 2 cont'd



- Need additional 6 m of packing
- Shell savings not as great
- Need 80 m^3 of packing, not 48

- Would be missed using ideal stages and HTUs
- 9.1-m upper bed built
- 14.2-m upper bed needed ☹

- Cost savings from swaging may have a height penalty
- Unrecognised, leads to failed design ☹ ☹ ☹

Final Comments

- Fast reactions
- Sharp changes inside columns
- Unstable operating regions
- Awareness for design and stable operation
- Tower geometry effect serious with packing
- Don’t use ideal stage based simulation
- Use only a real rate-based simulator
- ProTreat® widely accepted & thoroughly tested

ralph.weiland@ProTreat.com