Stable Operating Limits in Amine Treating Units

Scott Alvis, Ralph Weiland & Nate Hatcher
Optimized Gas Treating, Inc.
Houston, TX

What Limits?

- Rich amine loading – corrosion
- Maximum line velocities – scouring
- Tower hydraulic limits – packing & trays
- Operating T & P – degradation

✓ Are there operational stability limits?

Operational Stability Limits

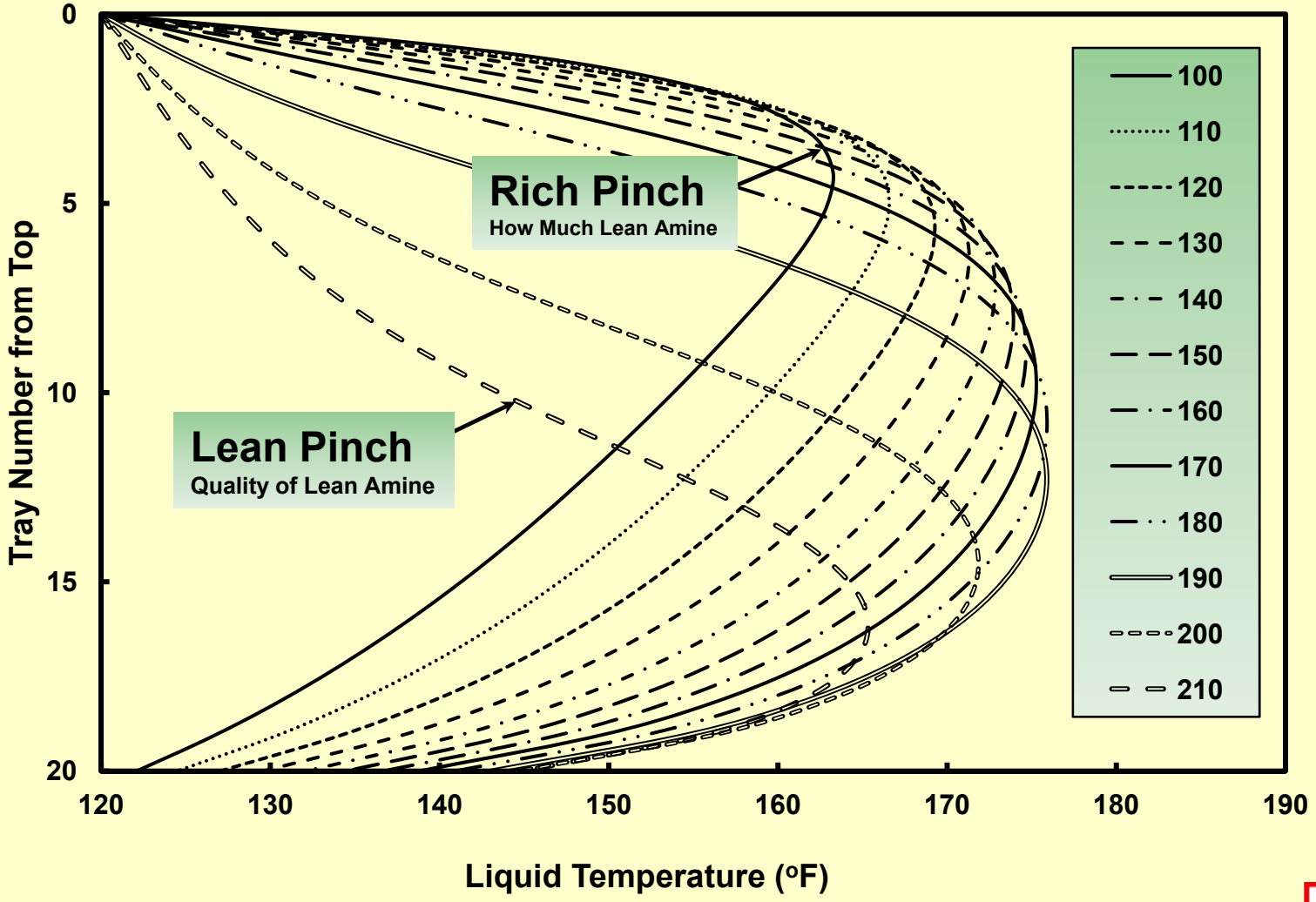
- Can be created by minimizing OPEX
  - Minimize solvent rates
  - Minimize reboiler energy
  - Maximize gas flow
  - Push plant as hard as you can
    - May end up going over a cliff
  - When and how badly?

Absorber Operation

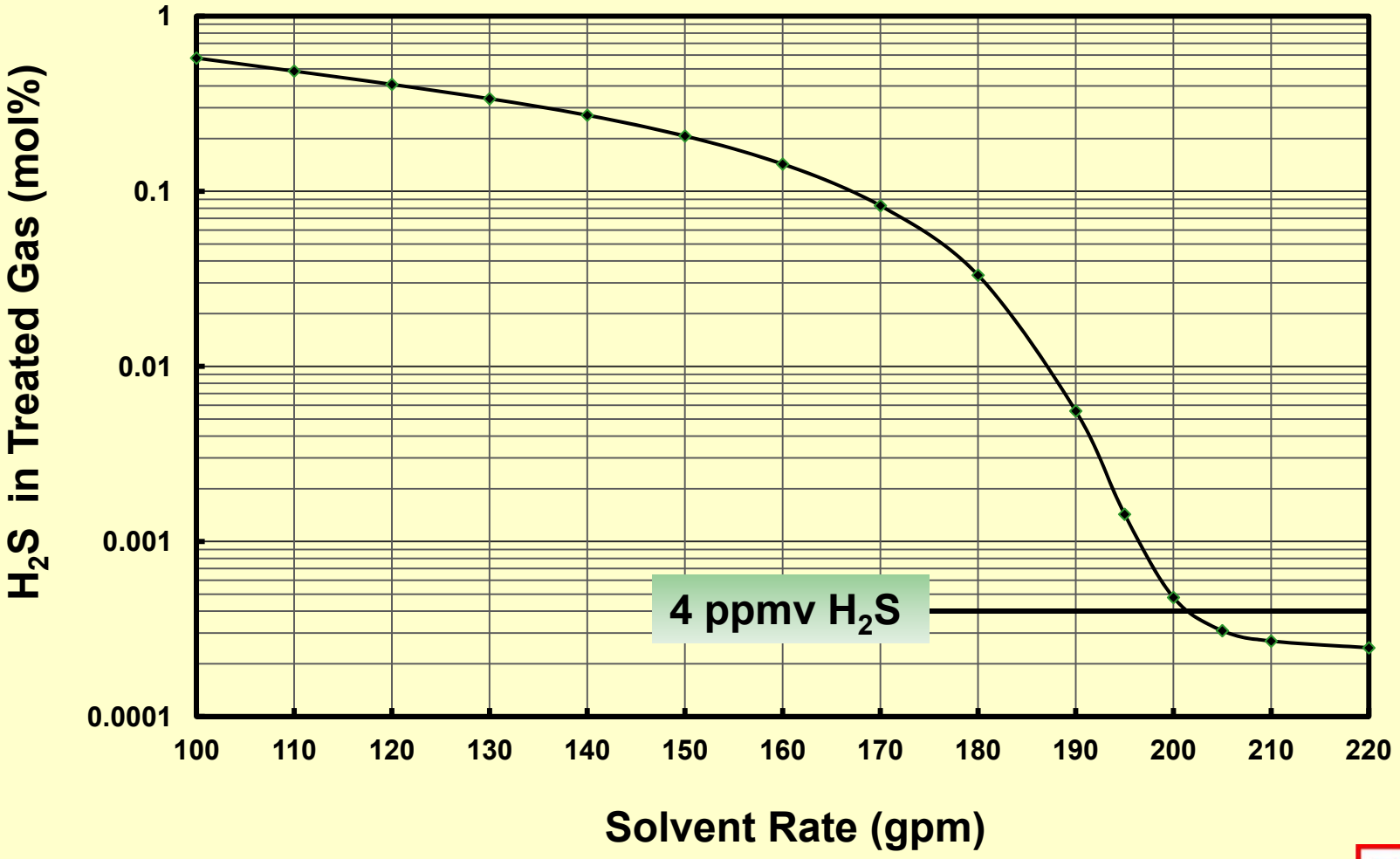
System	CO_2 Kinetics
Selective MDEA	Slow
MEA removing 5% CO_2	Fast
Piperazine-activated MDEA on 20% CO_2	Very Fast

Understanding Performance
Through Simulated Tower Profiles

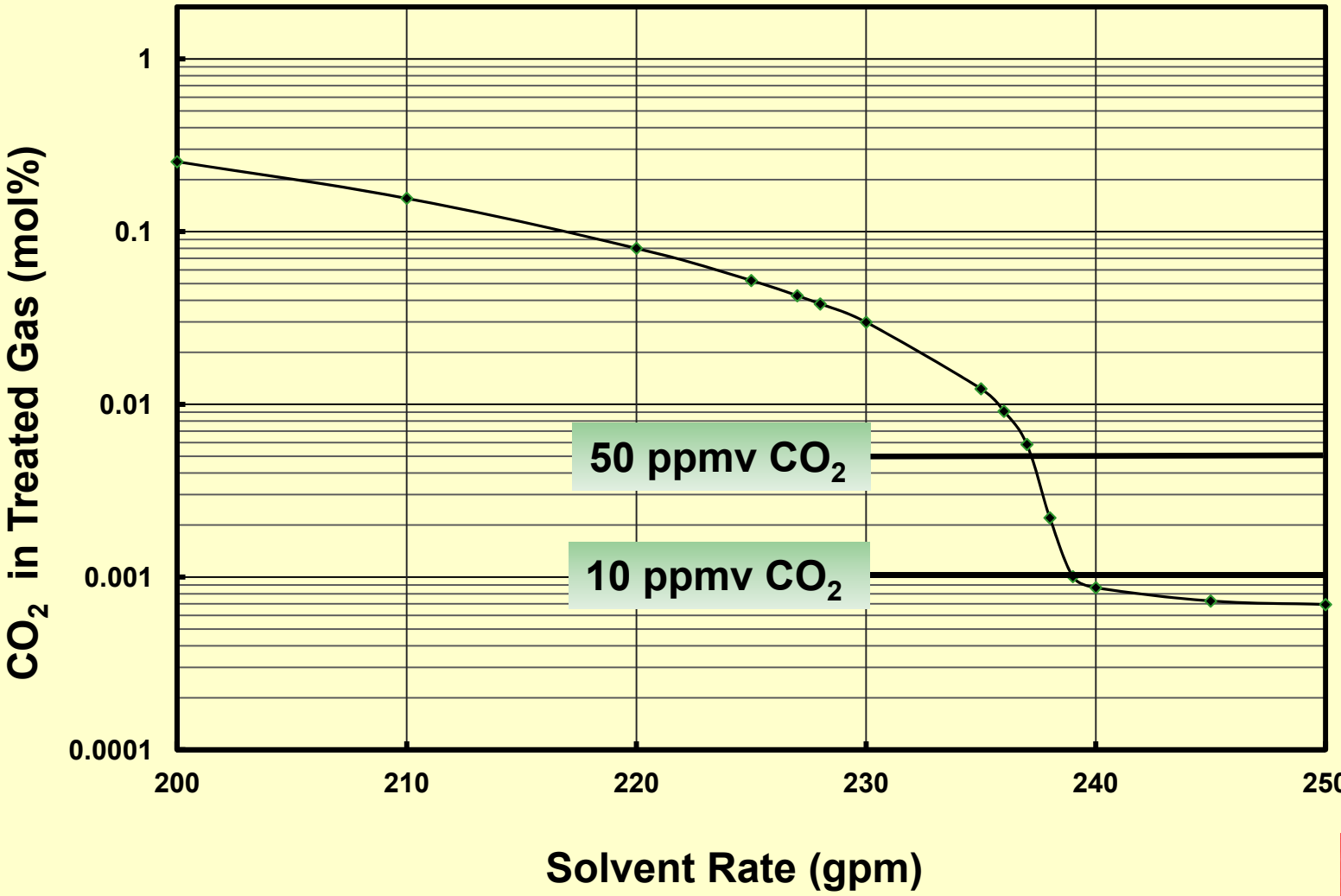
MDEA – 2.5% H_2S + 2.0% CO_2



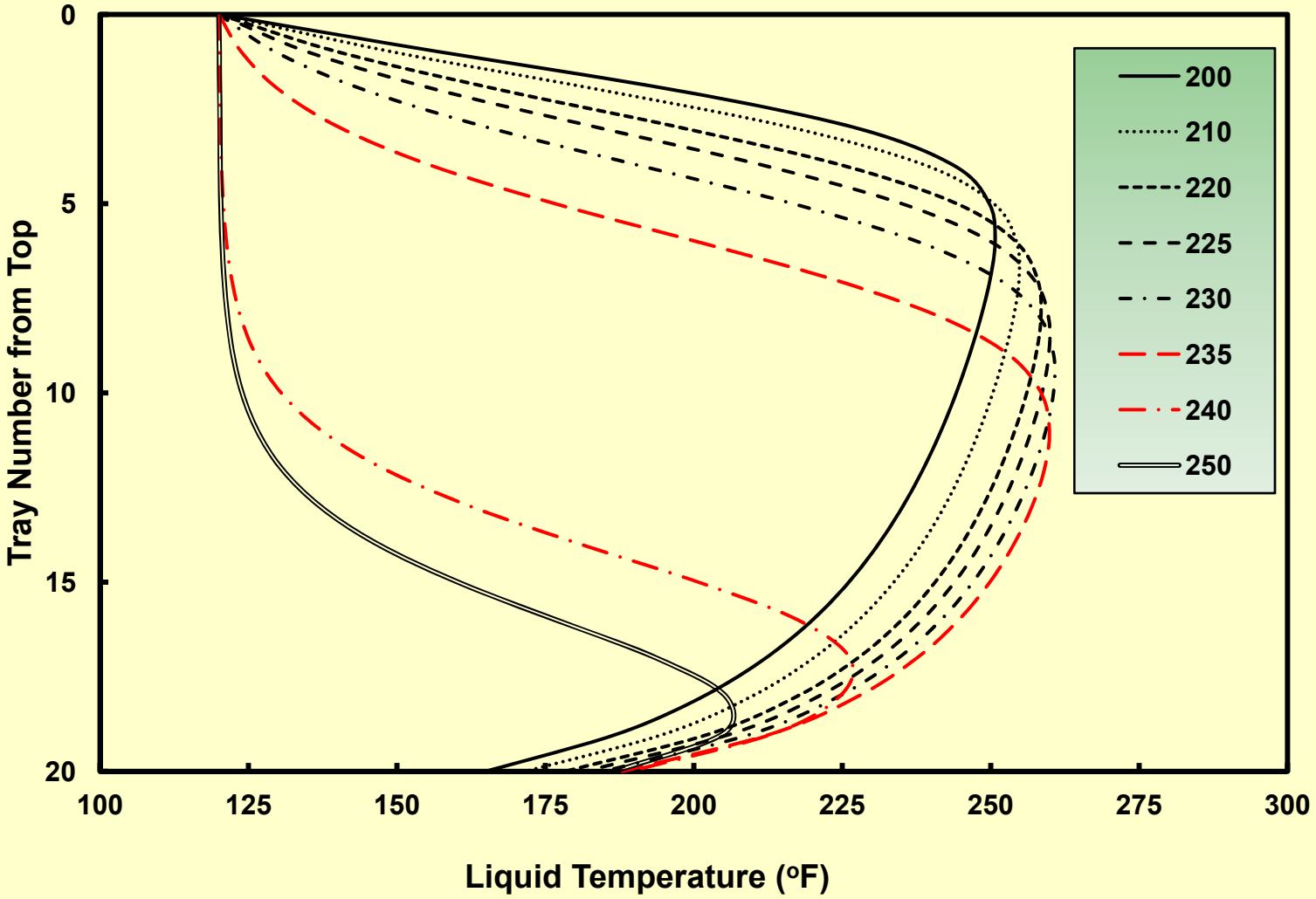
MDEA – 2.5% H_2S + 2.0% CO_2



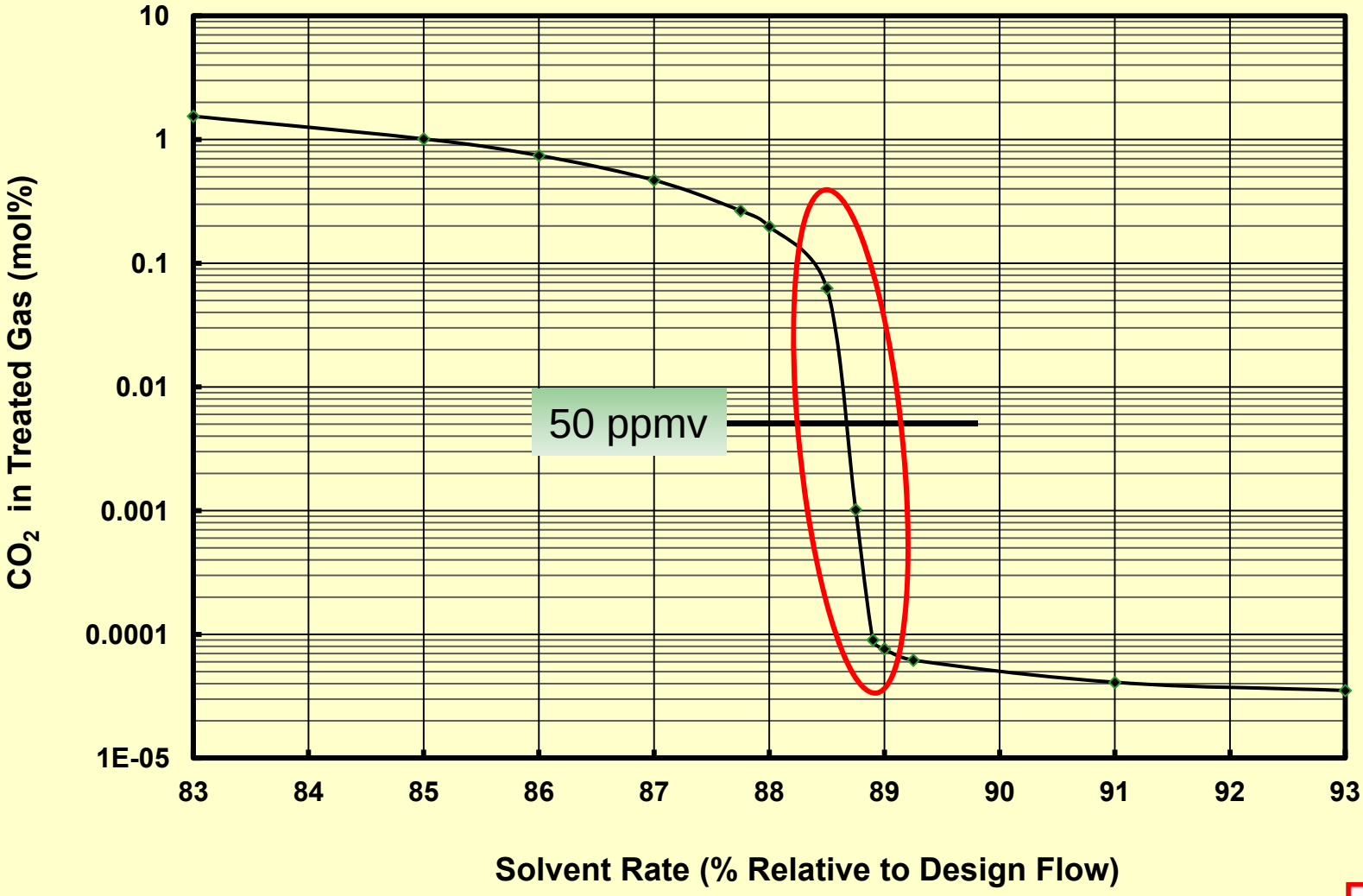
MEA – 5.0% CO_2


1
0.1
0.01
0.001
0.0001
200
210
220
230
240
250
CO_2 in Treated Gas (mol%)
50 ppmv CO_2
10 ppmv CO_2
Solvent Rate (gpm)

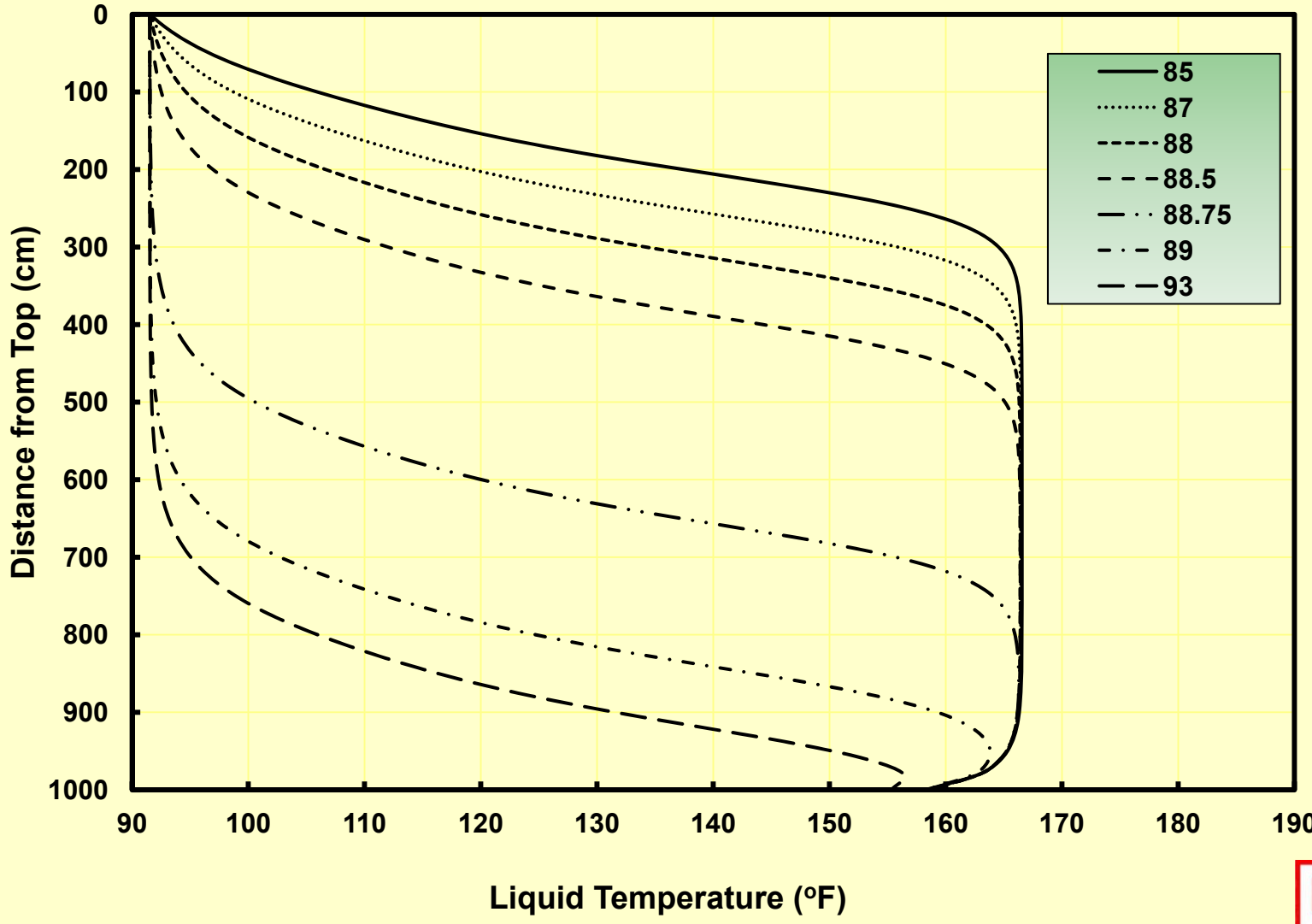
MEA – 5.0% CO_2


Tray Number from Top
0
5
10
15
20
100
125
150
175
200
225
250
275
300
Liquid Temperature (°F)
200
210
220
225
230
235
240
250

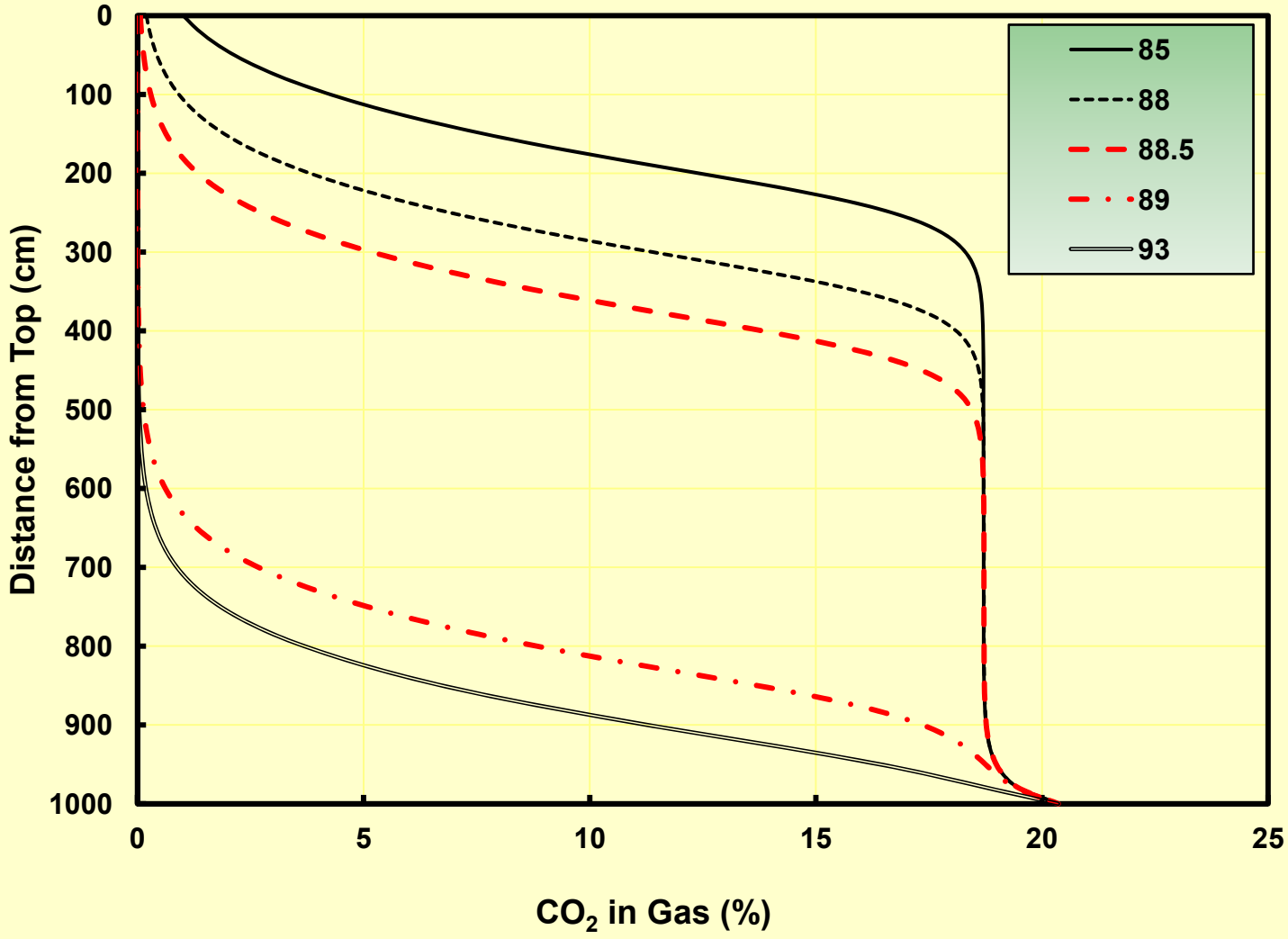
Piperazine + MDEA – 20% CO_2



Piperazine + MDEA – 20% CO_2



Piperazine + MDEA – 20% CO_2



Piperazine + MDEA – 20% CO_2

- **Normal Operation:**
  - Fast CO_2 reaction → Most CO_2 absorbed in bottom 2 m
  - Next 3 m polish
  - Upper 5 m superfluous

- **Below Minimum Solvent Flow**
  - Bottom 5 m superfluous
  - Next 3 m do most absorption
  - Top 2 m insufficient to polish, so…
  - CO_2 breaks through

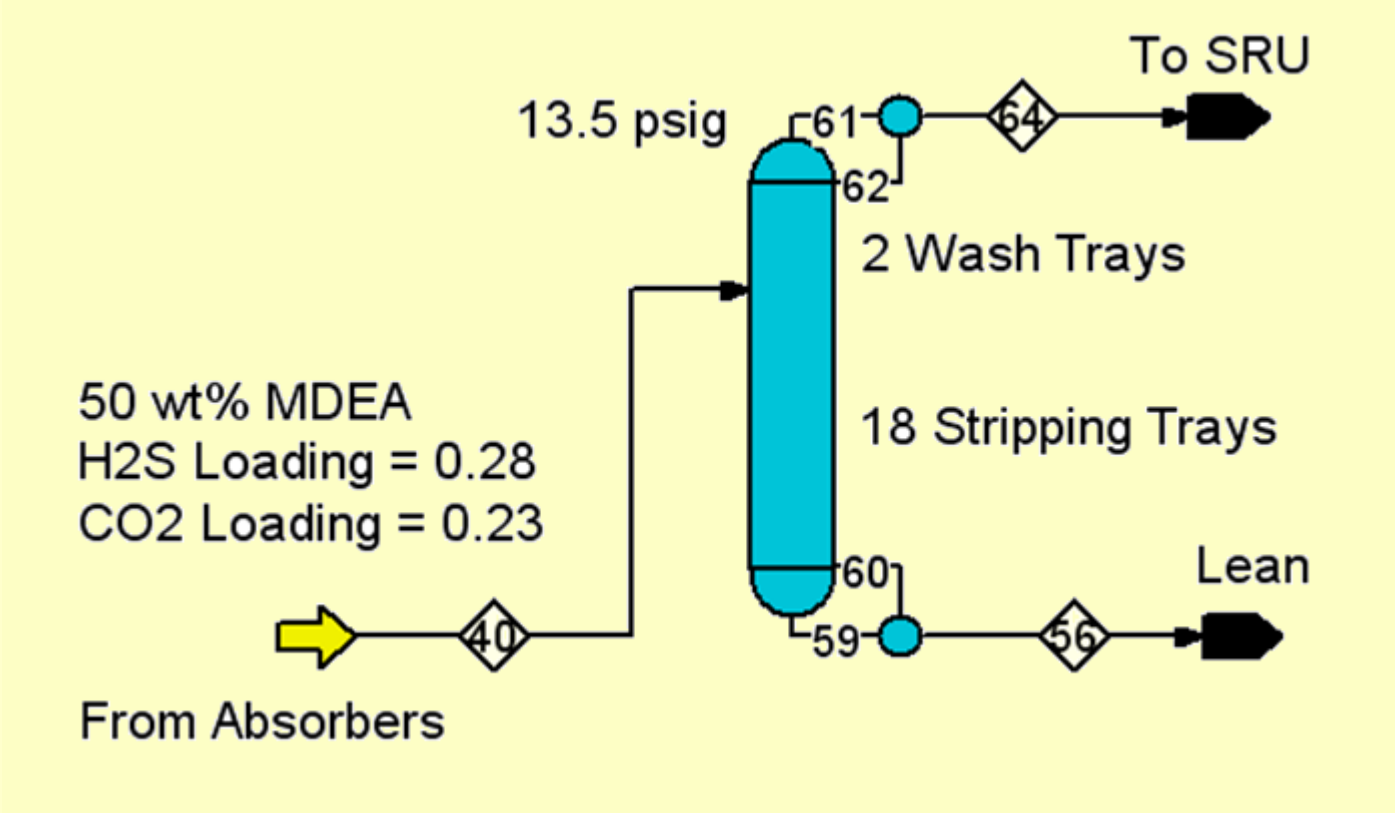
Absorber Summary

- Breakthrough most sudden with fastest CO_2 kinetics
- Breakthrough sensitive to:
  - Solvent rate
  - Gas CO_2 content
  - Gas flow
- If all you have is ideal stages and efficiencies, you'll never see the train coming.
- With fast kinetics there is no warning; when you fall over the cliff it can be a long way to the bottom!

Regenerators

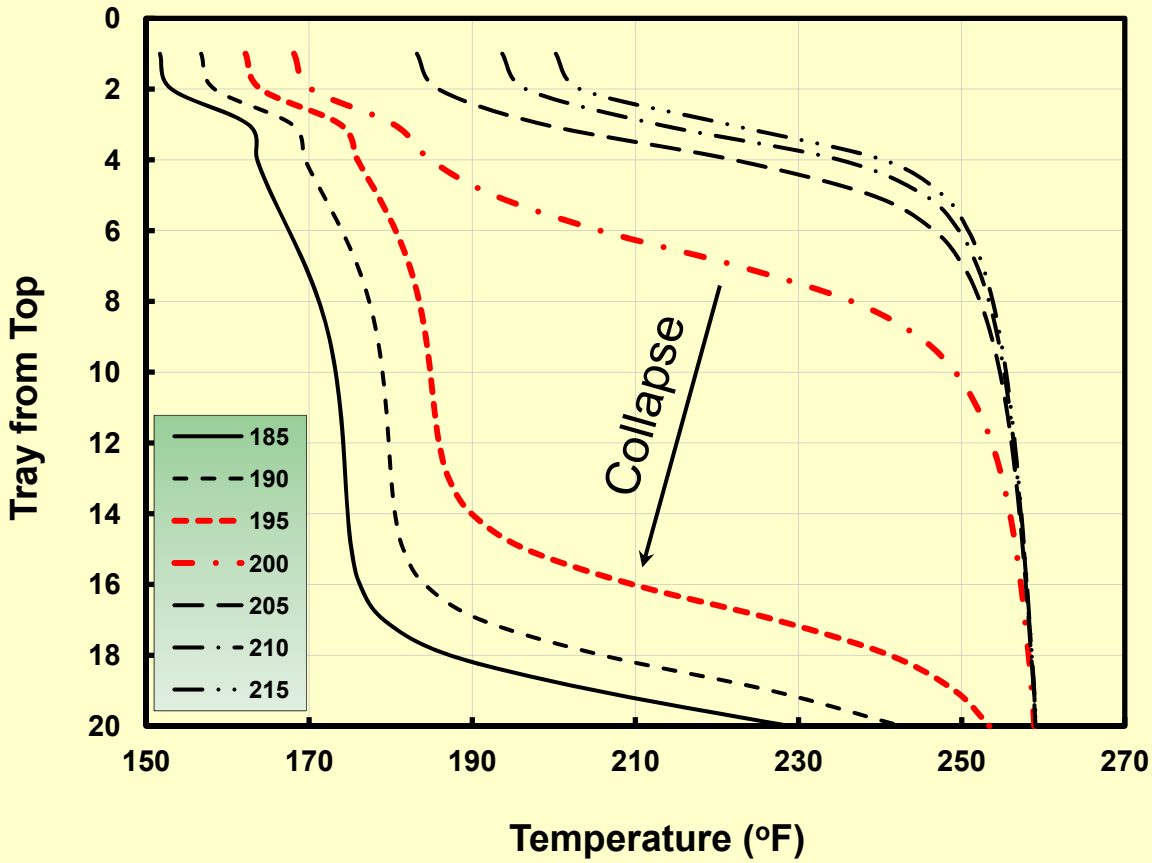
- Boilup rate usually fairly high
- Stainless metallurgy allows lower boilup rates
- Low reboiler duties typical in
  - Post-combustion carbon capture
  - Ammonia plant revamps from HotPot to PZ-MDEA
- Over-boiled to under-boiled transition
  - Can be sudden
  - Lead to plant instability
  - Could be caused by
    - Throttling steam/hot oil flow
    - Changing solvent & acid gas loads on regenerator
    - Loss of cross-exchanger efficiency (e.g., fouling)

Regenerators



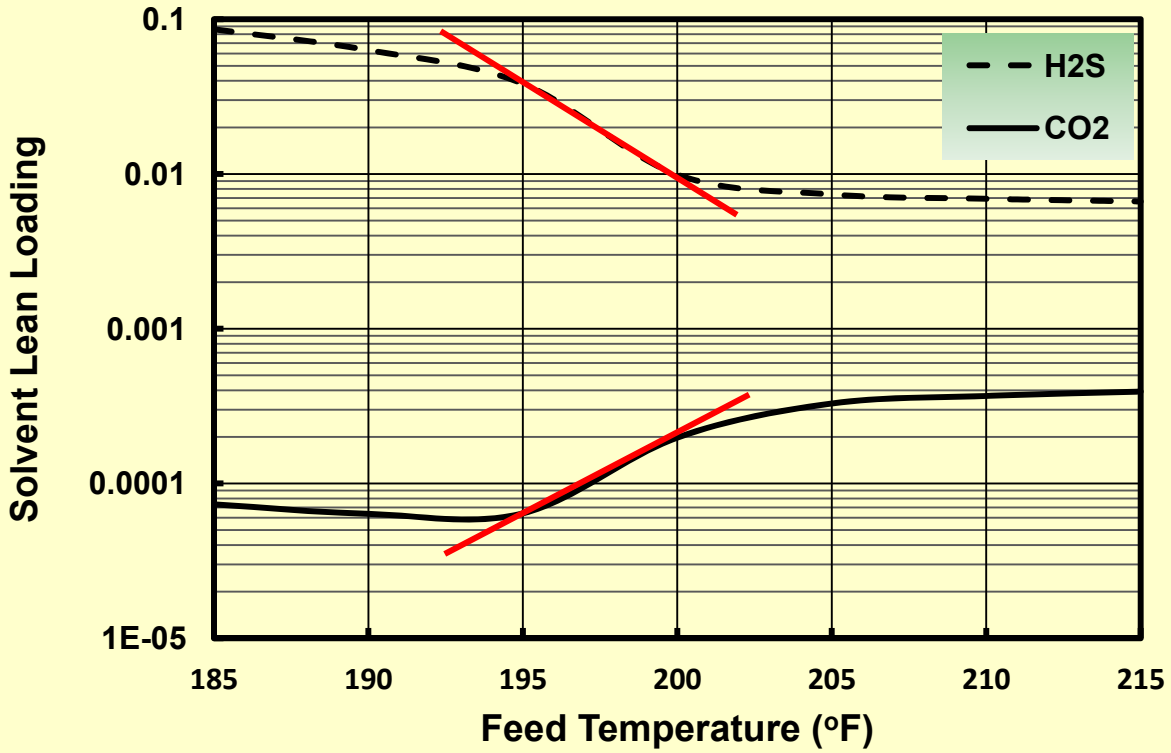
Regenerators

Effect of rich amine feed temperature



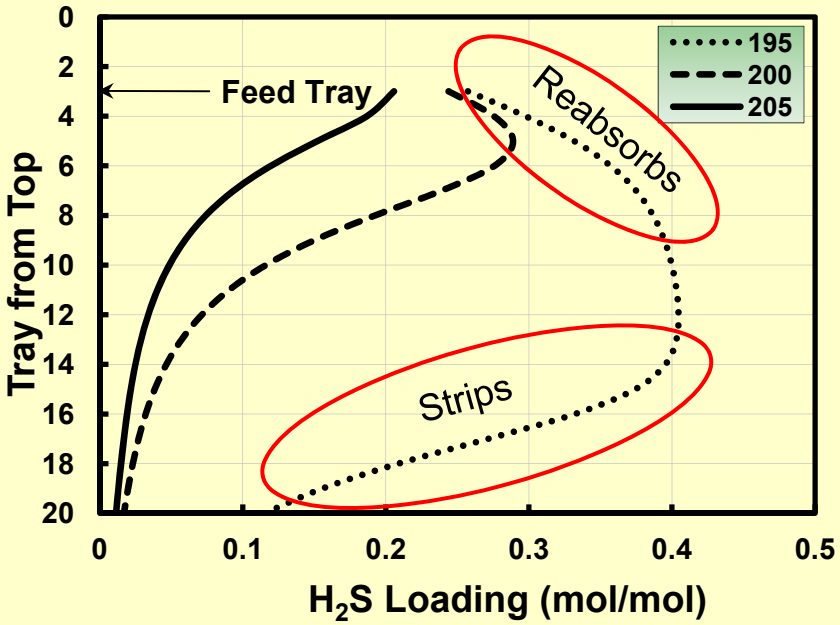
Regenerators

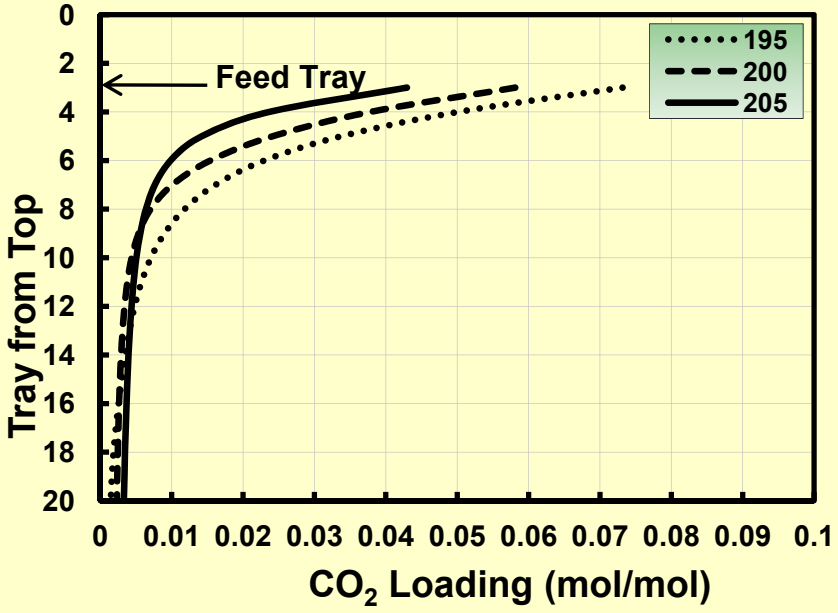
Effect of rich amine feed temperature



Regenerators

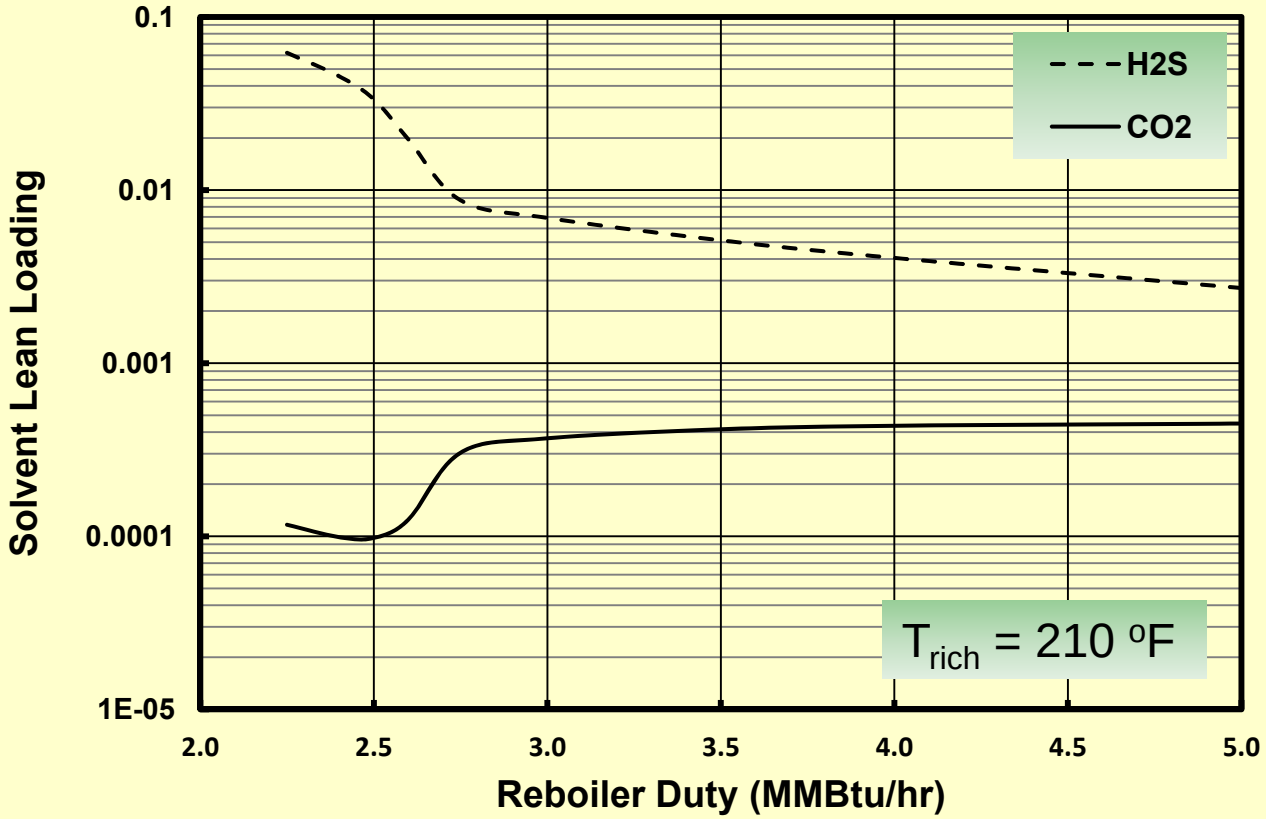
Effect of rich amine feed temperature





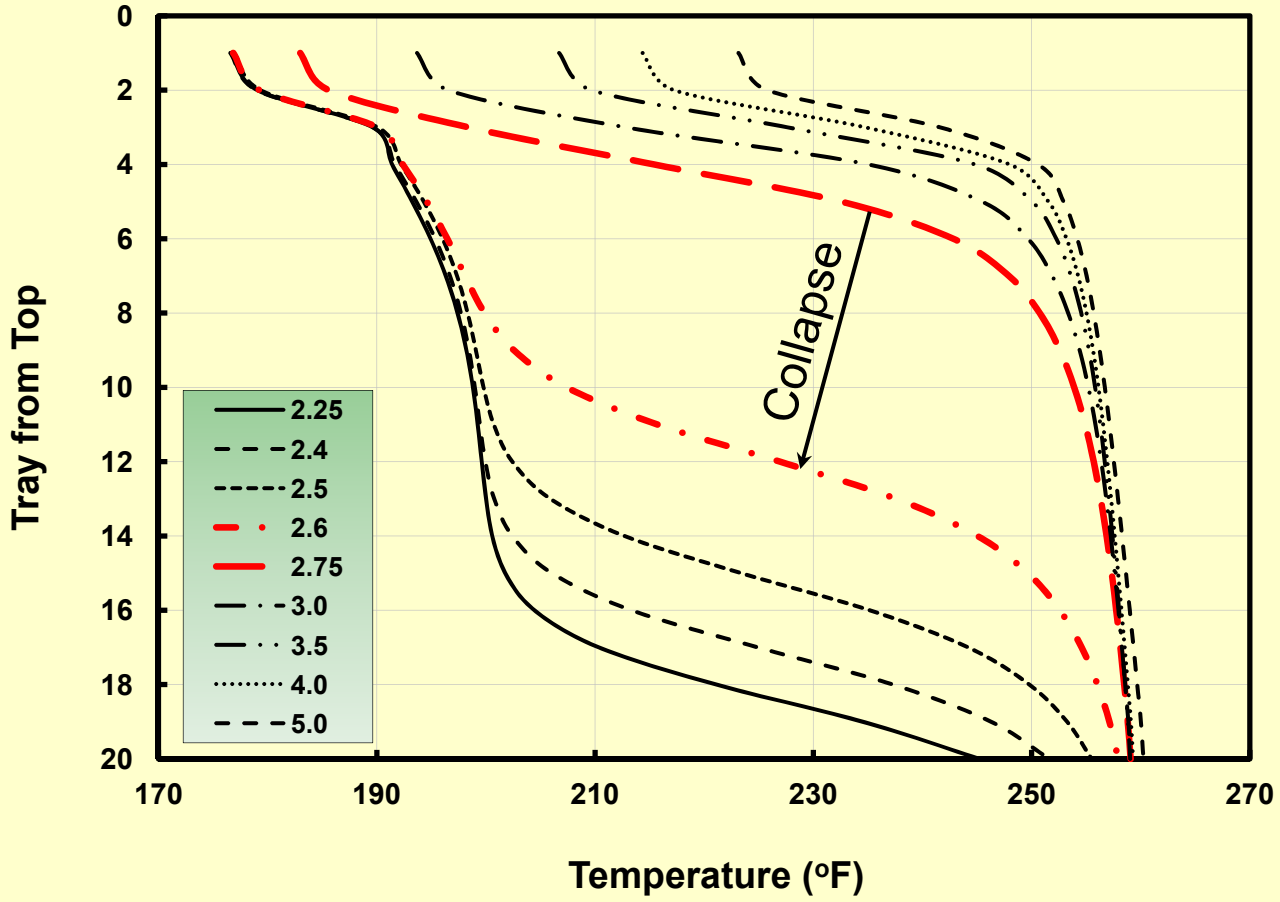
Regenerators

Reboiler Duty



Regenerators

Reboiler Duty



Summary

- Relative insensitivity of stripping to modest changes in reboiler duty until…
- Point of collapse of stripping steam flow
- But regenerators don't seem to go unstable, just harder to operate

- Absorbers with very fast CO_2 kinetics can become unstable if operated too close to minimum solvent rate
- Cannot operate in unstable region
- Without tower profiles, analysis is impossible
- Minimum solvent rate marks the edge of an operational cliff. Don't fall over!