Acid Gas Removal Options for Minimizing Methane Emissions

Innovative Technologies for the Oil & Gas Industry: Product Capture, Process Optimization, and Pollution Prevention

Targa Resources and the Gas Processors Association

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epa.gov/gasstar

Acid Gas Removal: Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion

Methane Losses from Acid Gas Removal

- There are 290 acid gas removal (AGR) units in gas processing plants[1]
  - Emit 644 MMcf annually[1]
  - 6 Mcf/day emitted by average AGR unit[1]
  - Most AGR units use an amine process or Selexol™ process
  - Several new processes have recently been introduced to the gas processing industry

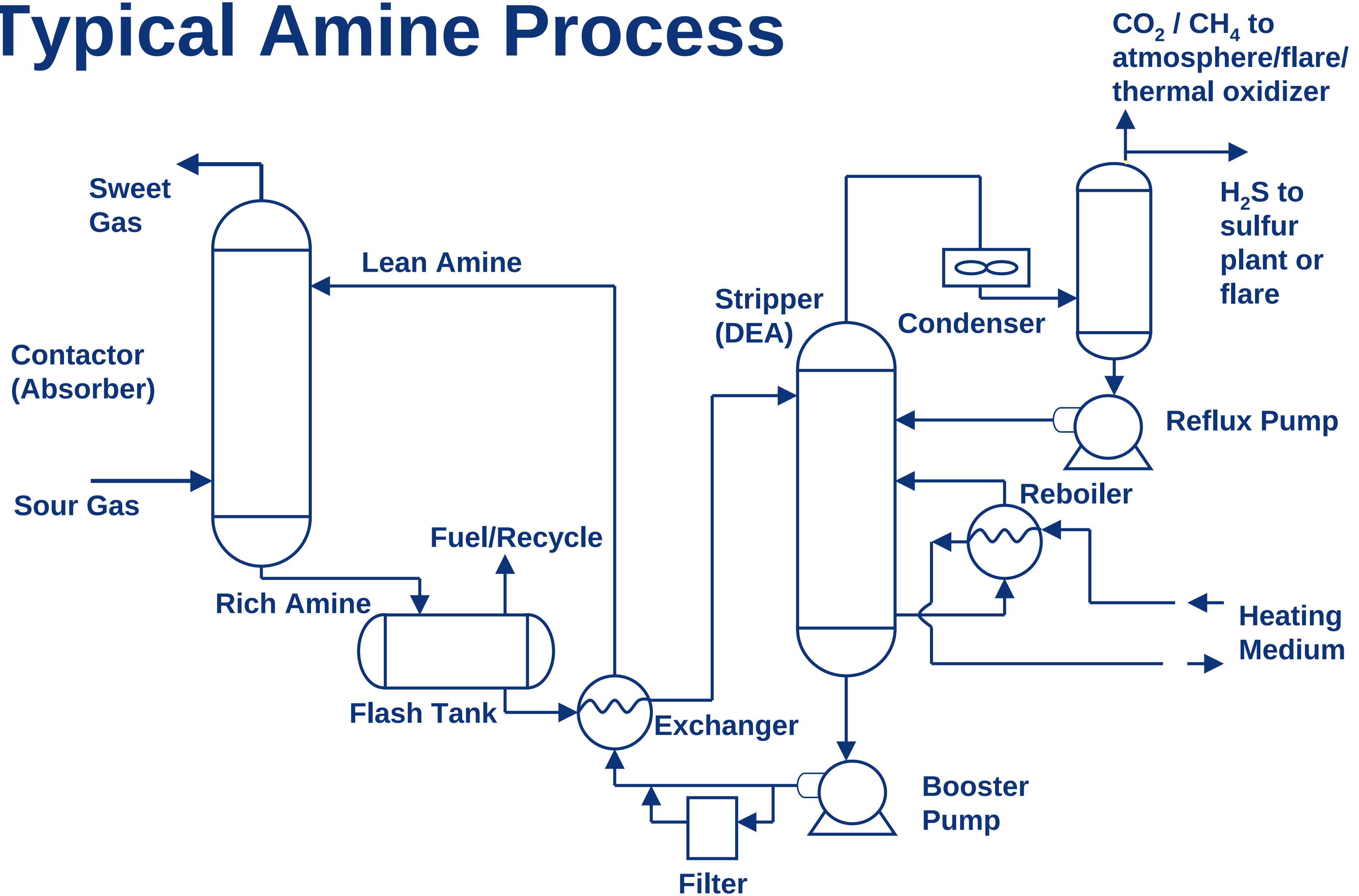
[1]Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2004

What is the Problem?

- 1/3 of U.S. gas reserves contain CO_2 and/or N_2[1]
- Wellhead natural gas may contain acid gases
  - H_2S, CO_2, are corrosive to gathering/boosting and transmission lines, compressors, pneumatic instruments and distribution equipment
- Acid gas removal processes have traditionally used an amine to absorb acid gas
- Amine regeneration strips acid gas (and absorbed methane)
  - CO_2 (with methane) is typically vented to the atmosphere, flared, or recovered for EOR
  - H_2S is typically flared or sent to sulfur recovery

[1]www.engelhard.com/documents/GPApaper2002.pdf

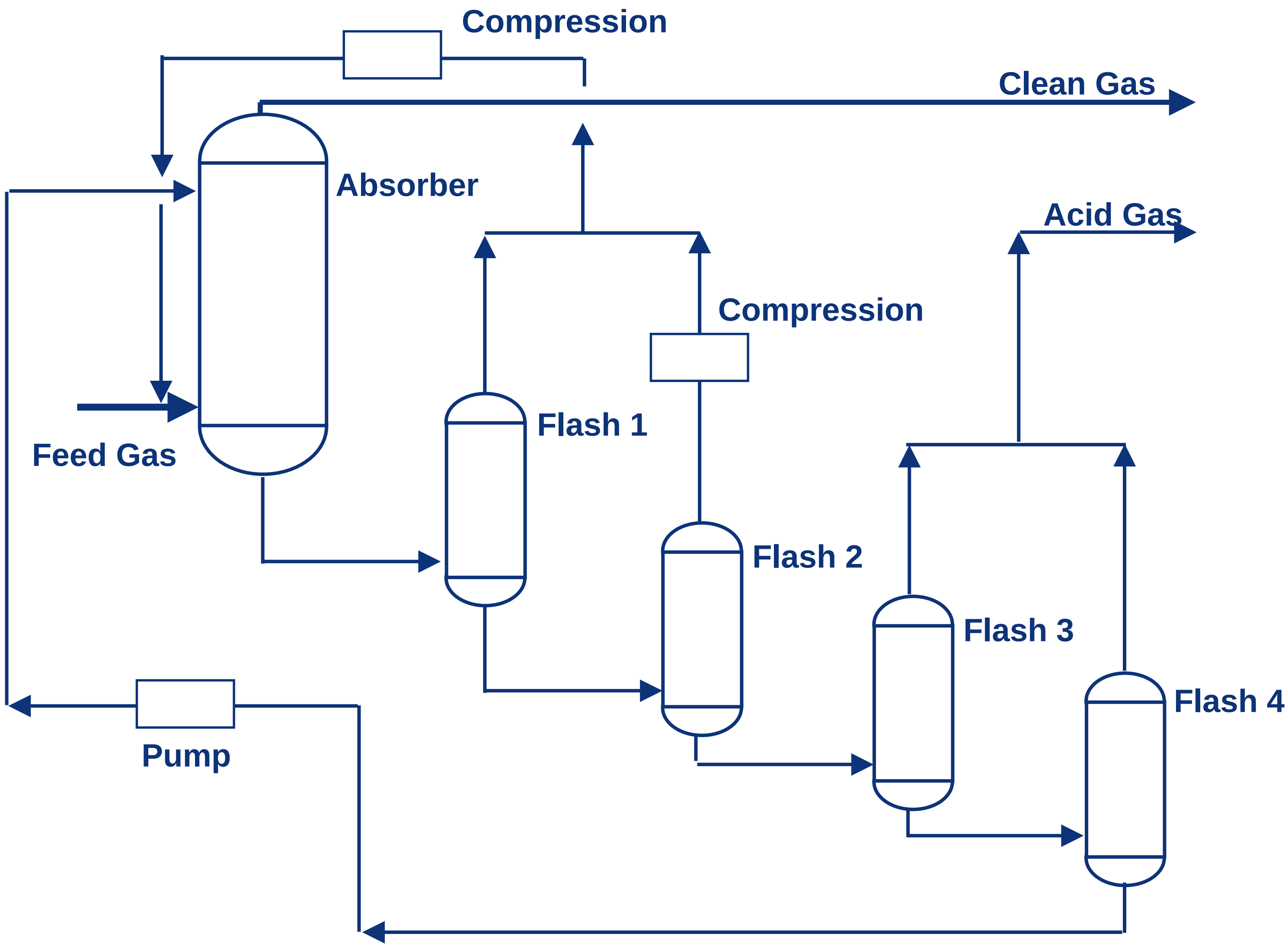
Typical Amine Process



Methane Recovery - New Acid Gas Removal Technologies

- GTI & Uhde Morphysorb® Process
- Engelhard Molecular Gate® Process
- Kvaerner Membrane Process
- Primary driver is process economics, not methane emissions savings
- Reduce methane venting by 50 to 100%

Morphysorb® Process



Morphysorb® Process

- Morphysorb® absorbs acid gas but also absorbs some methane
  - Methane absorbed is 66% to 75% lower than competing solvents[1]
- Flash vessels 1 & 2 recycled to absorber inlet to minimize methane losses
- Flash vessels 3 & 4 at lower pressure to remove acid gas and regenerate Morphysorb®

[1] Oil and Gas Journal, July 12, 2004, p 57

Is Recovery Profitable?

- Morphysorb® can process streams with high (>10%) acid gas composition
- 30% to 40% Morphysorb® operating cost advantage over DEA or Selexol™ [2]
  - 66% to 75% less methane absorbed than DEA or Selexol™
  - About 33% less THC absorbed[2]
  - Lower solvent circulation volumes
- At least 25% capital cost advantage from smaller contactor and recycles[2]
- Flash recycles 1 & 2 recover ~80% of methane that is absorbed[1]

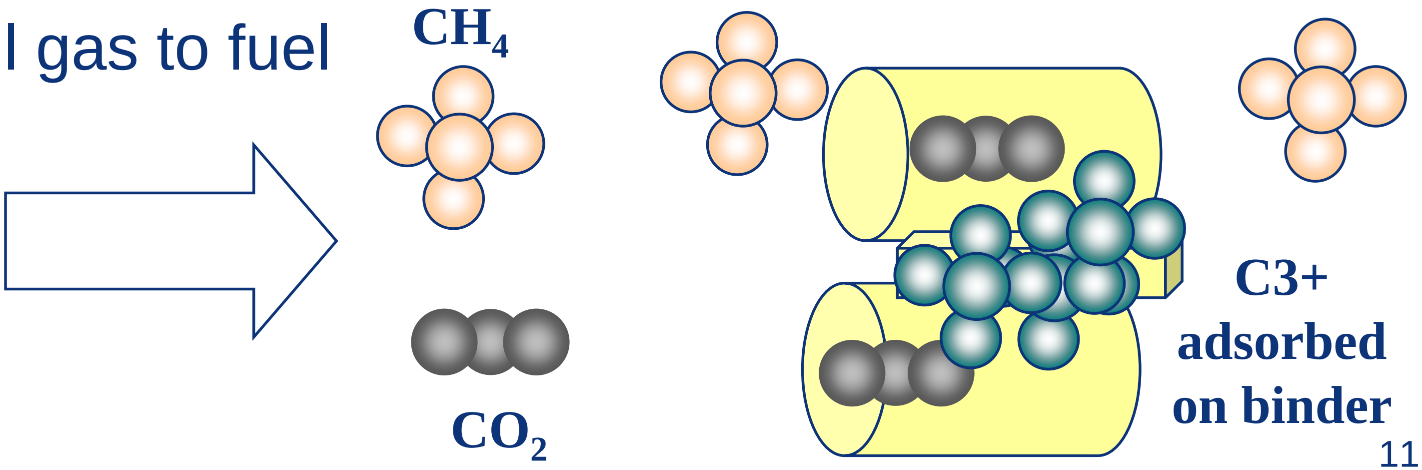
[1]Oil and Gas Journal, July 12, 2004, p 57, Fig. 7
[2]GTI

Industry Experience - Duke Energy

- Kwoen plant does not produce pipeline-spec gas
  - Separates acid gas and reinjects it in reservoir
  - Frees gathering and processing capacity further downstream
- Morphysorb® used in process unit designed for other solvent
- Morphysorb® chosen for acid gas selectivity over methane
  - Less recycle volumes; reduced compressor horsepower

Methane Recovery - Molecular Gate® CO_2 Removal

- Adsorbs acid gas contaminants in fixed bed
- Molecular sieve application selectively adsorbs acid gas molecules of smaller diameter than methane
- Bed regenerated by depressuring
  - 5% to 10% of feed methane lost in “tail gas” depressuring
  - Route tail gas to fuel



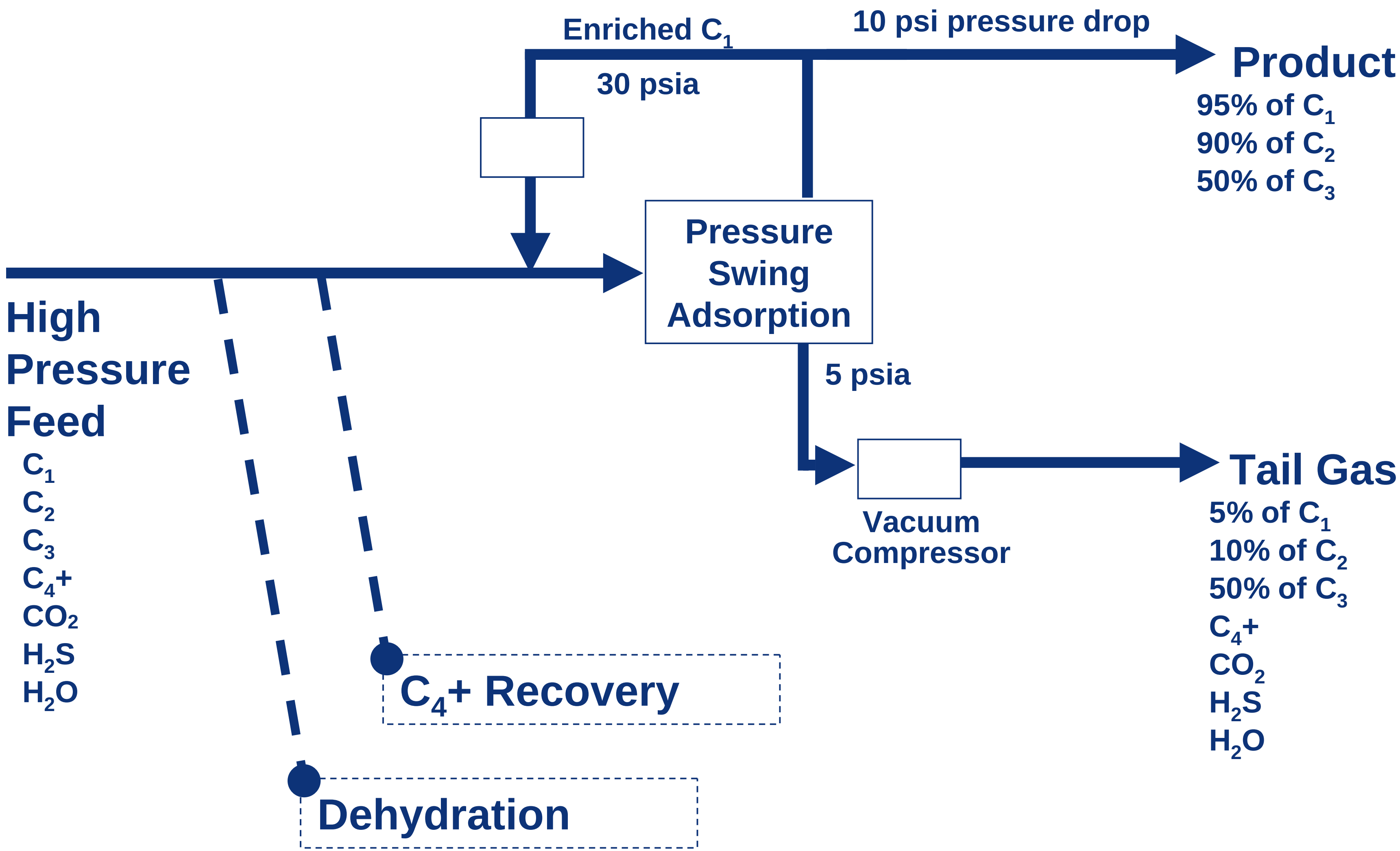
Molecular Gate® Applicability

- Lean gas
  - Gas wells
  - Coal bed methane
- Associated gas
  - Tidelands Oil Production Co.
    - 1 MMcf/d
    - 18% to 40% CO_2
    - Water saturated
  - Design options for C_4+ in tail gas stream
    - Heavy hydrocarbon recovery before Molecular Gate®
    - Recover heavies from tail gas in absorber bed
    - Use as fuel for process equipment

Engelhard Molecular Gate system at a facility in Southern Illinois

www.engelhard.com

Molecular Gate® CO_2 Removal



Industry Experience - Tidelands Molecular Gate® Unit

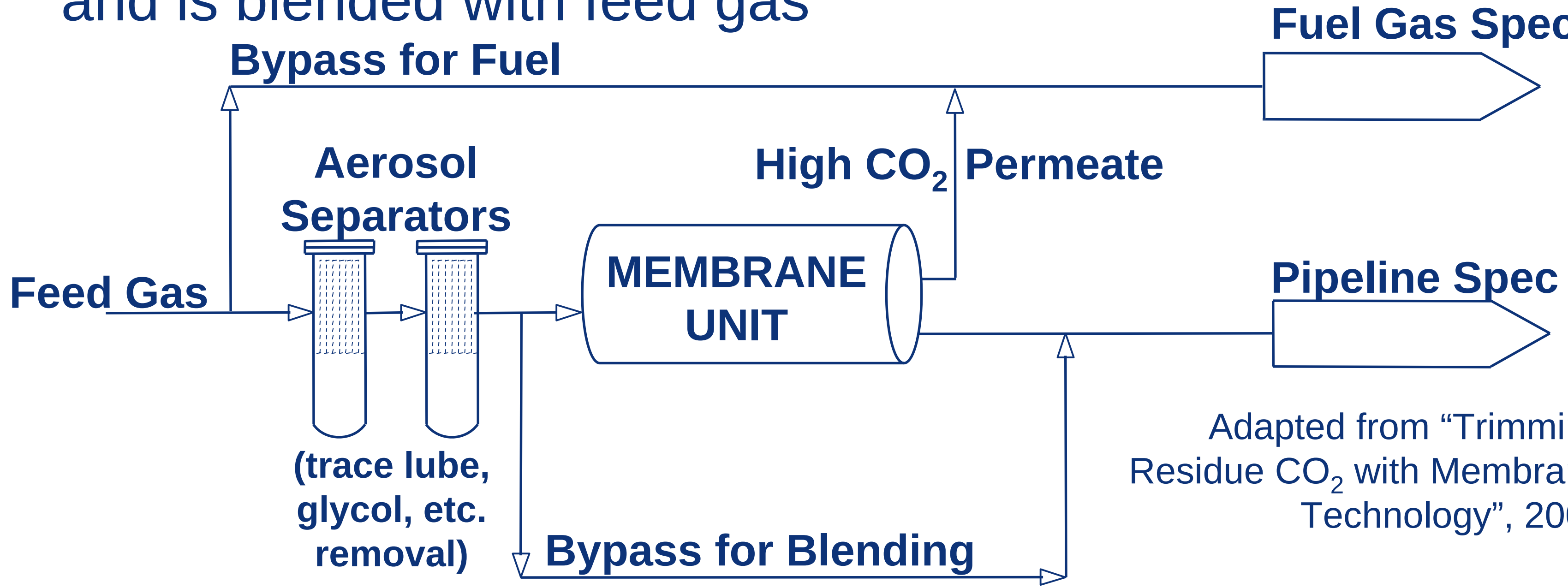
- First commercial unit started in May 2002
- Process up to 10 MMcf/d
- Separate recycle compressor is required
- No glycol system is required
- Heavy HC removed with CO_2
- Tail gas used for fuel is a key optimization: No process venting
- 18% to 40% CO_2 removed to pipeline specifications (2%)

Is Recovery Profitable?

- Molecular Gate® costs are 20% less than amine process
  - 9 to 35 ¢ / Mcf product depending on scale
- Fixed-bed tail gas vent can be used as supplemental fuel
  - Eliminates venting from acid gas removal
- Other Benefits
  - Allows wells with high acid gas content to produce (alternative is shut-in)
  - Can dehydrate and remove acid gas to pipeline specs in one step
  - Less operator attention

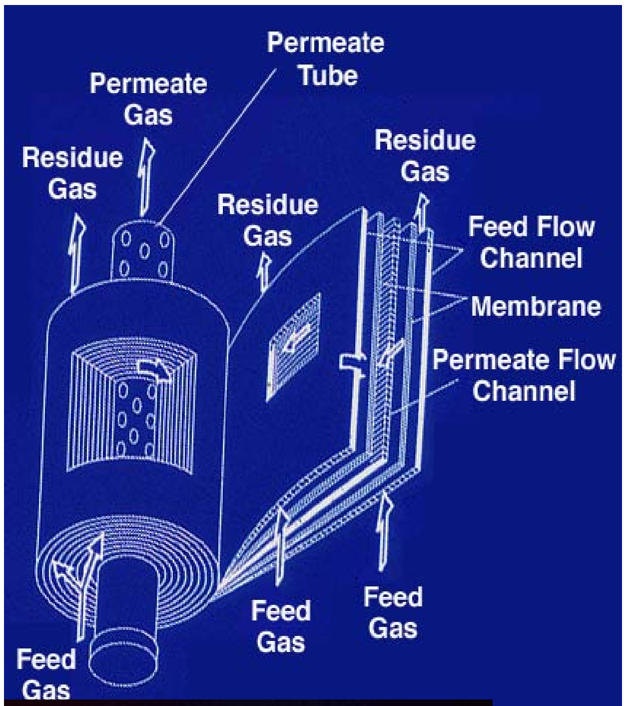
Kvaerner Membrane Process

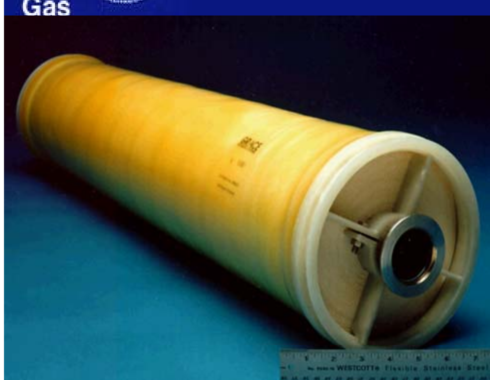
- Membrane separation of CO_2 from feed gas
  - Cellulose acetate spiral wound membrane
- High CO_2 permeate (effluent or waste stream) exiting the membrane is vented or blended into fuel gas
- Low CO_2 product exiting the membrane exceeds pipeline spec and is blended with feed gas



Adapted from "Trimming Residue CO_2 with Membrane Technology", 2005

Kvaerner Membrane Technology





- CO_2 (and some methane) diffuse axially through the membrane
- High-CO_2 permeate exits from center of tube; enriched product exits from outer annular section
- One application for fuel gas permeate
  - Methane/CO_2 waste stream is added with fuel gas in a ratio to keep compressor emissions in compliance
- Design Requirements
  - Upstream separators remove contaminants which may foul membrane
  - Line heater may be necessary

Industry Experience – Duke Energy

- Kvaerner process installed at Mewborn processing plant in Colorado, 2003
- Problem: Sales gas CO_2 content increasing above the 3% pipeline spec

Duke Energy Field Services

- Evaluated options
  - Blend with better-than-spec gas
    - Not enough available
  - Use cryogenic NGL recovery to reject CO_2
    - Infrastructure/capital costs too high
  - Final choice: membrane or amine unit

Industry Experience

- Membrane chosen for other advantages; zero emissions is added benefit
  - 65% less capital cost than amine unit
  - ~10% operating cost (compared to amine)
  - ~10% operator man hours (compared to amine)
  - 1/3 footprint of amine unit
  - Less process upsets
  - Less noise
  - Less additional infrastructure construction
- Typical Process conditions

Flow Into Membrane	Membrane Residue (Product)	Membrane Permeate
22.3 MMcf/d	21	1.3
70 to 110 ^oF	70 to 110	70 to 110
800 to 865 psia	835	55
3% CO_2	2%	16%
84% C_1	89%	77%
13% C_2+	9%	7%
~0% H_2O	~0%	~0%
~0% H_2S	~0%	~0%

Is Recovery Profitable?

- Costs
  - Conventional DEA AGR would cost $4.5 to $5 million capital, $0.5 million O&M per year
  - Kvaerner Membrane process cost $1.5 to $1.7 million capital, $0.02 to $0.05 million O&M per year
- Optimization of permeate stream
  - Permeate mixed with fuel gas, $5/Mcf fuel credit
  - Only installed enough membranes to take feed from >3% to >2% CO_2, and have an economic supplemental fuel supply for compressors
- In operation for over 2 years
- Offshore Middle East using NATCO membrane process on gas with 90% CO_2, achieving pipeline spec quality

Comparison of AGR Alternatives

	Amine (or Selexol™) Process	Morphysorb® Process	Molecular Gate® CO_2	Kvaerner Membrane
Absorbent or Adsorbent	Water & Amine (Selexol™)	Morpholine Derivatives	Titanium Silicate	Cellulose Acetate
Methane Savings	100%	66 to 75%	0%	0% or higher
Regeneration	Reduce Pressure & Heat	Reduce Pressure	Reduce Pressure to Vacuum	Replace Membrane ~5 years
Primary Operating Costs	Amine (Selexol™) & Steam	Electricity	Electricity	Nil
Capital Cost Operating Cost	100% 100%	75% 60% to 70%	<100% 80%	35% <10%

Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies an practices
- Actual costs and benefits