# Methane Emission Reductions in Oil and Gas Processing

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# Agenda

- U.S. Processing Sector Methane Emissions
- Overview of Technologies and Practices
- Methane Saving Opportunities
  - Compressors
  - Leak detection, quantification, and repair
  - Acid gas removal
- Contacts and Further Information

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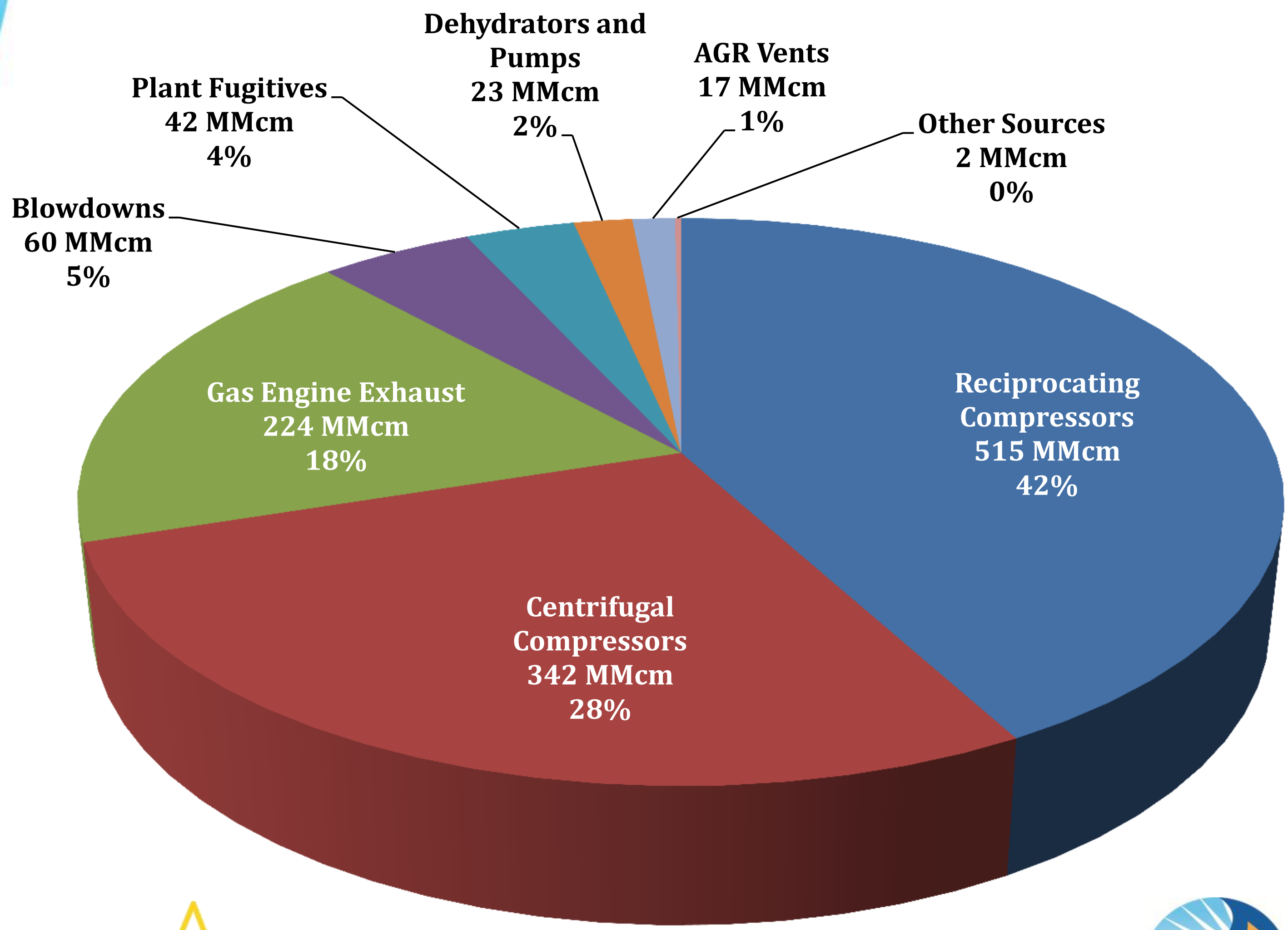
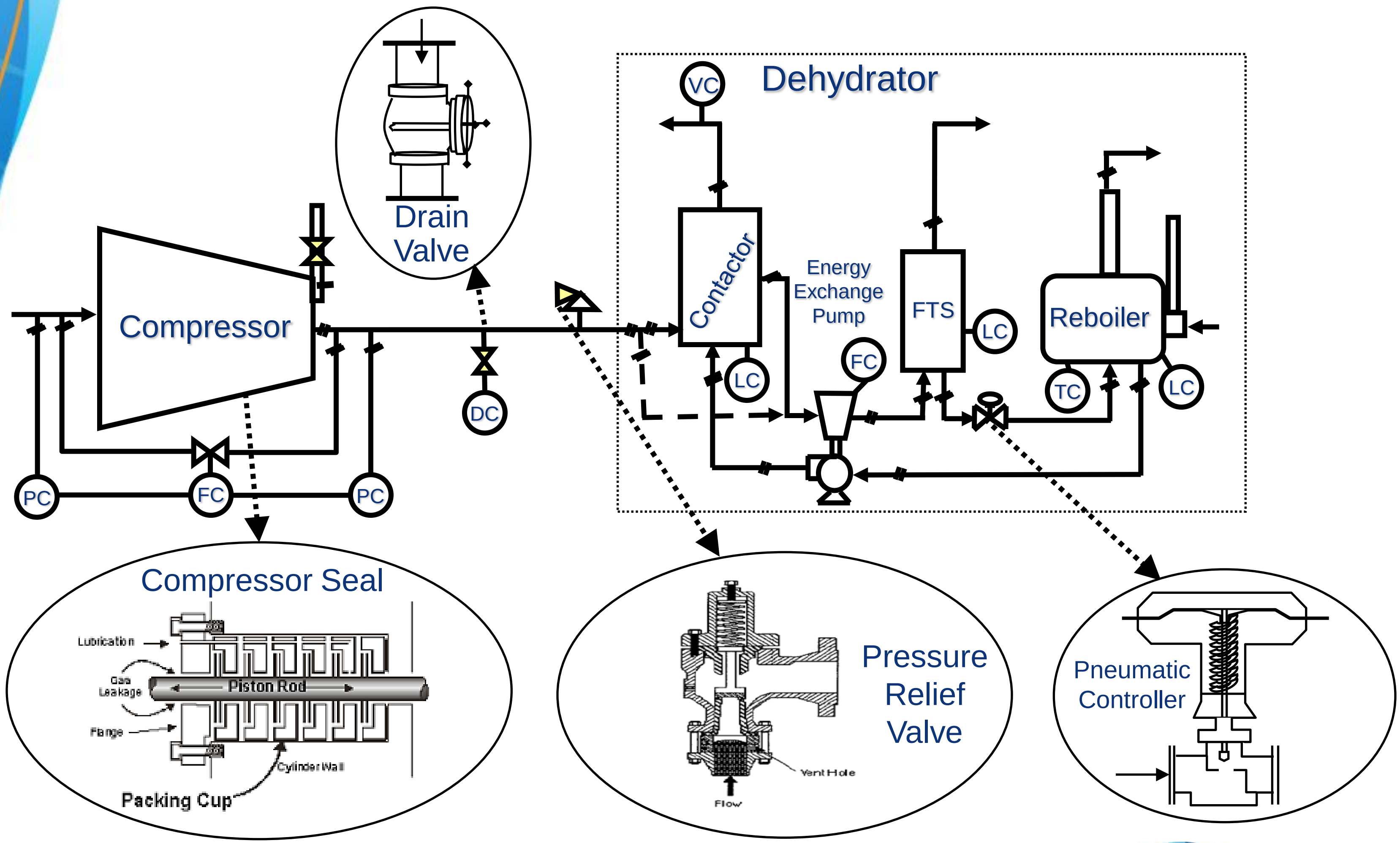
# 2010 U.S. Processing Sector Methane Emissions (1.2 Bcm)




EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2010.* April, 2012.

# Emissions Sources in Gas Gathering/Processing Plants

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# Overview of Technologies and Practices

## 30 technologies and practices that apply to the processing sector

- Reduce compressor venting with fewer startups
- **Begin leak detection, quantification and repair at processing plants**
- Eliminate unnecessary equipment and/or systems
- Pipe glycol dehydrator to vapor recovery unit
- Inspect and repair compressor station blowdown valves
- Convert gas-driven pneumatic devices to instrument air
- **Economic replacement of rod packing in reciprocating compressors**
- Install pressurized storage of condensate
- **Alternate acid gas removal technologies**
- Replace high-bleed pneumatic devices with low-bleed devices

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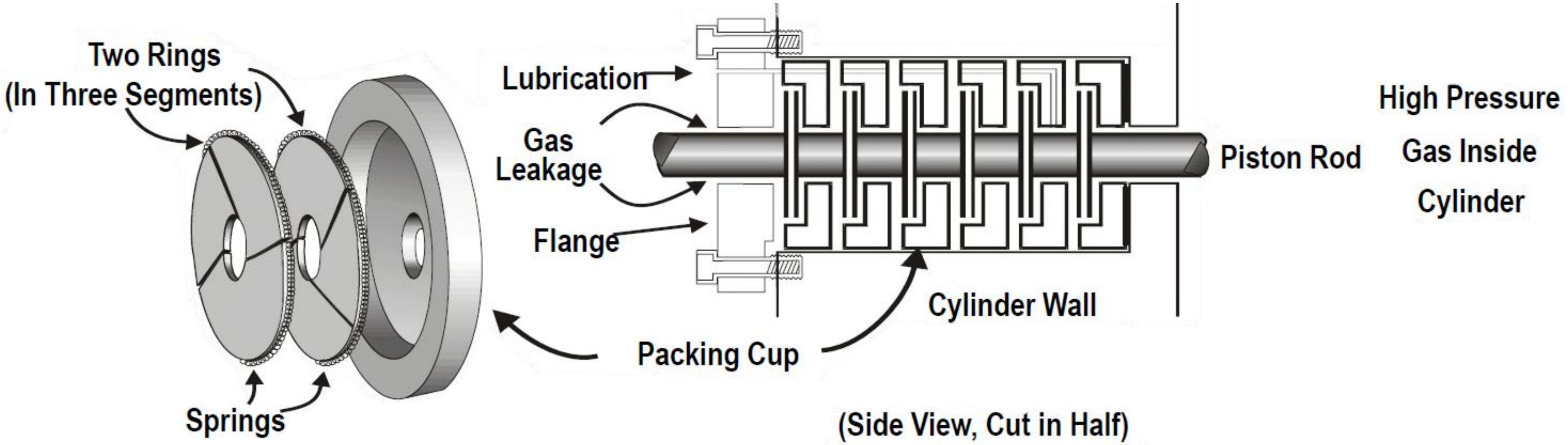
# Reciprocating Compressor Emissions Overview

- Reciprocating compressors rod packing leaks some gas by design
  - Flexible rings fit around the shaft to minimize leakage
  - Leakage still occurs through nose gasket, between packing cups, and between rings and shaft
  - Emissions can range between **0.3 to 25 m³/hour** depending on age of packing



# Reciprocating Compressor Emission Reductions

- Methane emissions can be reduce through economic replacement of rod packing
  - Measure rod packing leakage periodically over life of packing
  - Determine cost of packing replacement
  - Determine economic replacement threshold
    - Compare value of excess gas lost with worn packing to savings with new packing
  - Replace packing when leak reduction will pay back cost

$$\text{Economic Replacement Threshold (m}^3\text{/hr)} = \frac{CR \times DF \times 1000}{H \times GP}$$

Where:
***CR*** = Cost of replacement
***DF*** = Discount factor at interest *i*, over period *n*
***H*** = Hours of operation
***GP*** = Gas price per thousand cubic meters

$$DF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

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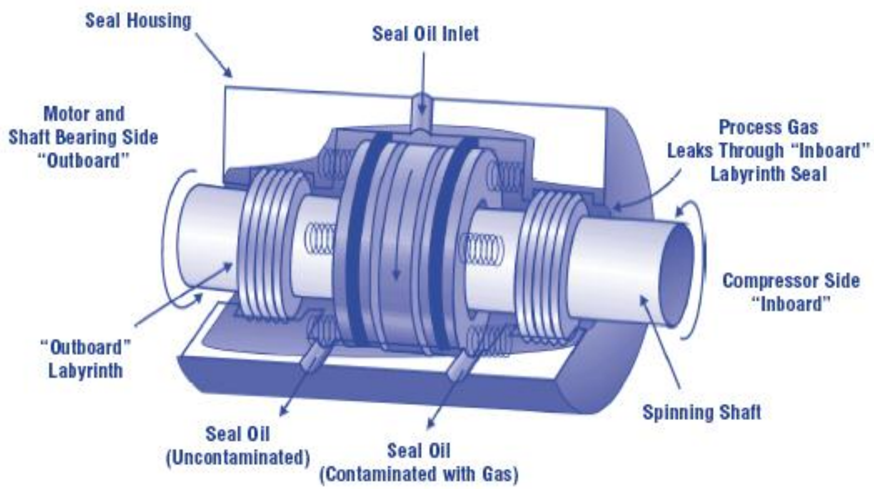
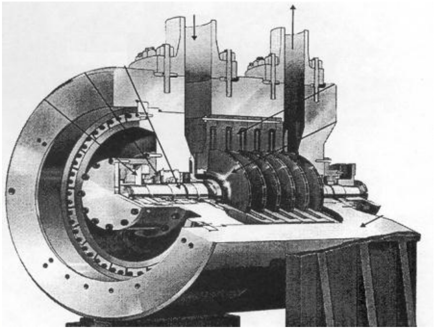
# Centrifugal Compressor Emissions Overview

- Centrifugal Compressors have seals around rotating shaft to prevent gas from escaping
  - Seals often use oil, called “wet seals”
- The majority of methane emissions occur through seal oil degassing which is often vented to the atmosphere
  - Oil is very effective at preventing leaks but also entrains a substantial amount of gas
  - Emissions from seal oil degassing vents can range between **1.1 to 5.7 m$^3$/minute**



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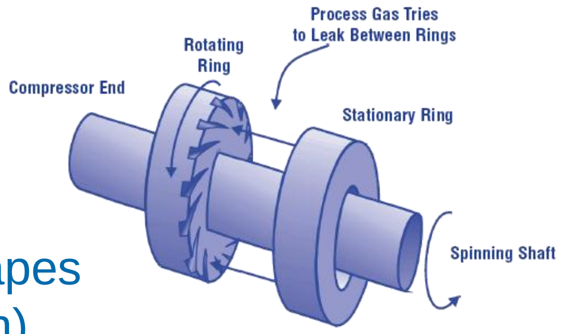
# Centrifugal Compressor Emission Reductions

- Converting wet seals to dry seals can drastically cut methane emissions
  - Dry seal springs press stationary ring in seal housing against rotating ring
  - At high rotation speed, gas is pumped between seal rings creating a high pressure barrier to leakage
  - Only a very small amount of gas escapes through the gap (0.01 to 0.08 $m^3$/min)




- Another alternative is to set up a vapory recovery system to capture vented methane from wet seals
  - Highly effective – captures up to 99% of otherwise vented gas
  - Requires less compressor downtime to set up
  - Easy to set up on older wet seal compressors

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# Leak Detection, Quantification, and Repair

- Directed Inspection and Maintenance (DI&M)
  - Cost-effective practice, by definition
  - Find and fix significant leaks
  - Strictly tailored to company's needs
- Real-time detection of methane leaks using infrared technology
  - Quicker identification & repair of leaks
  - Screen hundreds of components an hour
  - Screen inaccessible areas simply by viewing them
- Identified leaks can be measured by a Hi Flow® sampler, calibrated bag, turbine meter, or other technology

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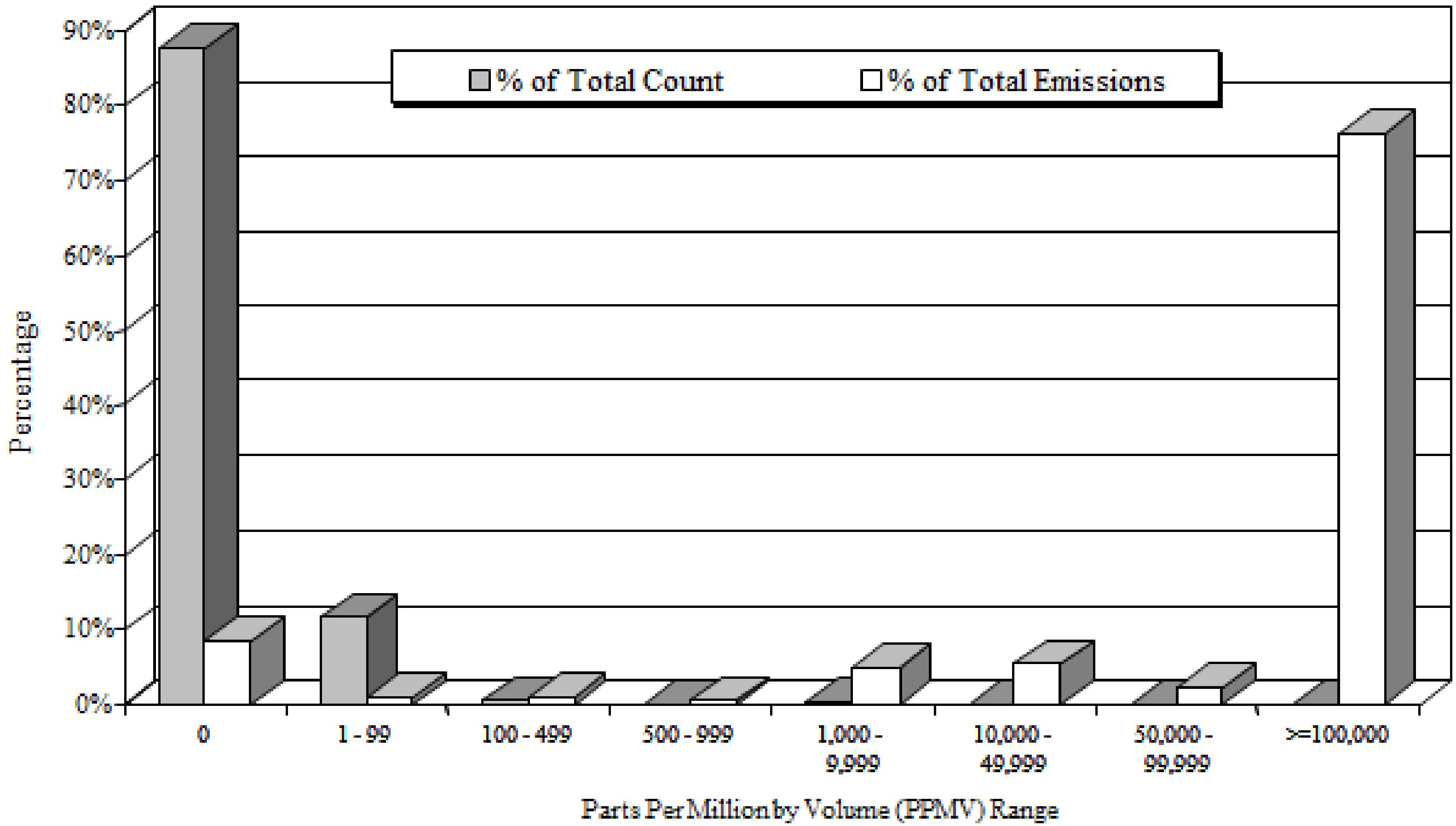
# Component Count vs. Emissions

**Distribution of component count and estimated emissions by screening range**




Source: Robinson, et al. "Refinery Evaluation of Optical Imaging to Locate Fugitive Emissions." Journal of Air and Waste Management. Volume 57, July 2007.

# Is Recovery Profitable?

| Repair the Cost-Effective Components | | | |
|---|---|---|---|
| **Component** | **Annual Value of Lost Gas ($)** | **Estimated Repair Cost ($)** | **Payback (months)** |
| Plug Valve: Valve Body | 12,642 | 200 | 0.2 |
| Union: Fuel Gas Line | 12,156 | 100 | 0.1 |
| Threaded Connection | 10,446 | 10 | 0.0 |
| Distance Piece: Rod Packing | 7,650 | 2,000 | 3.1 |
| Open-Ended Line | 6,960 | 60 | 0.1 |
| Compressor Seals | 5,784 | 2,000 | 4.1 |
| Gate Valve | 4,728 | 60 | 0.2 |

Source: Hydrocarbon Processing, May 2002

Based on $3/MMBtu gas price

# Acid Gas Removal (AGR) – What is the Problem?

- Wellhead natural gas may contain acid gases
  - Hydrogen sulfide ($H_2S$) and $CO_2$ are corrosive to pipelines, compressors, instruments, and distribution equipment
- Acid gas removal processes have traditionally used an aqueous amine solution to absorb acid gas
  - These solutions absorb methane along with the acid gases
- Amine regeneration strips acid gas and absorbed methane
  - If the acid gas is $CO_2$ it is typically vented to the atmosphere, flared, or recovered for enhanced oil recovery (EOR)
  - $H_2S$ is typically flared (low concentrations) or sent to the sulfur recovery unit (high concentrations)
- There are two commercial alternatives to DEA absorption
  - Membrane
  - Molecular Gate®

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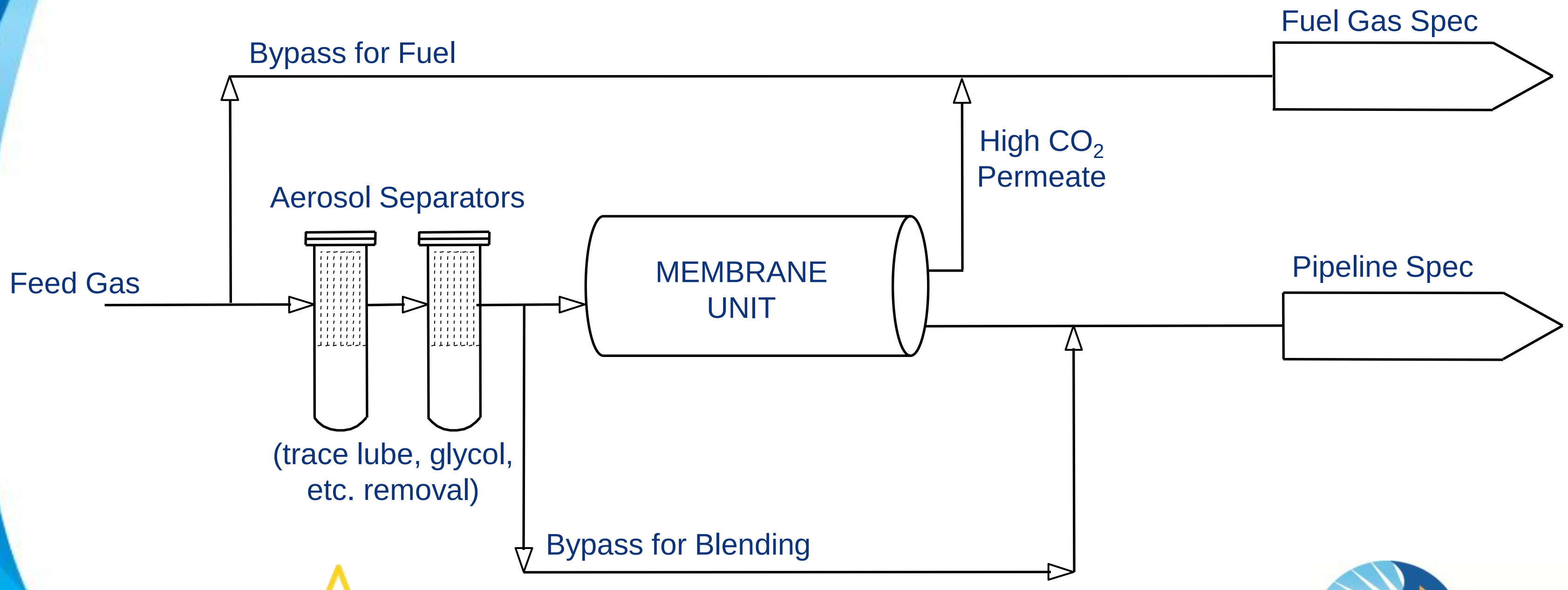
# AGR Alternatives: Membrane Separator

- Membrane separation of $CO_2$ from feed gas
- 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", OGJ 2005

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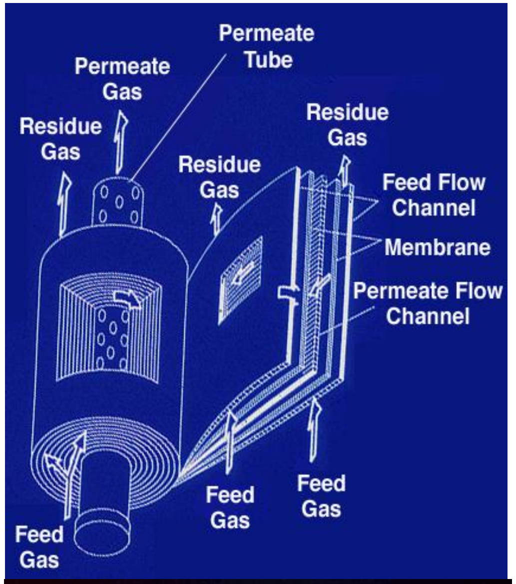
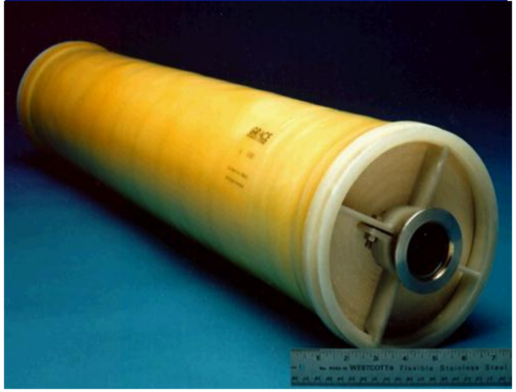
# Membrane Economics: Is Recovery Profitable?

- Cost comparison
  - DEA AGR cost $4.5 to $5 million capital, $0.5 million operation and maintenance (O&M) per year
  - 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, $175/Mcm fuel credit
  - Only install enough membranes to take feed from >3% to <2% $CO_2$
  - Expand with additional membranes



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# AGR Alternatives: Molecular Gate®

- Molecular Gate® adsorbs acid gas ($CO_2$ and $H_2S$) in fixed bed
- Molecular sieve application selectively adsorbs acid gas molecules of smaller diameter than methane
- Bed regenerated by depressuring
  - 10% of feed methane lost in depressuring
  - Route tail gas to fuel
- Applicable to lean gas sources

# Molecular Gate® Economics: Is Recovery Profitable?

- Molecular Gate® costs are 20% less than amine process
- 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

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# Comparison of AGR Alternatives

| | Amine (or Selexol™) Process | Kvaerner Membrane | Molecular Gate® $CO_2$ |
|---|---|---|---|
| **Absorbent or Adsorbent** | Water & amine (Selexol™) | Cellulose acetate | Titanium silicate |
| **Methane Savings Compared to Amine Process** | -- | Methane in permeate gas combusted for fuel | Methane in tail gas combusted for fuel |
| **Regeneration** | Reduce pressure & heat | Replace membrane about 5 years | Reduce pressure to vacuum |
| **Primary Operating Costs** | Amine (Selexol™) & steam | Nil | Electricity |
| **Capital Cost** | 100% | 35% | <100% |
| **Operating Cost** | 100% | <10% | 80% |

# Contact and Further Information

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## Global Methane Initiative

globalmethane.org

## Recommended Technologies (Arabic)

epa.gov/gasstar/tools/arabic/index.html