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

- Reciprocating Compressors: 515 MMcm (42%)
- Centrifugal Compressors: 342 MMcm (28%)
- Gas Engine Exhaust: 224 MMcm (18%)
- Blowdowns: 60 MMcm (5%)
- Plant Fugitives: 42 MMcm (4%)
- Dehydrators and Pumps: 23 MMcm (2%)
- AGR Vents: 17 MMcm (1%)
- Other Sources: 2 MMcm (0%)

Emissions Sources in Gas Gathering/Processing Plants

- Compressor
- Drain Valve
- PC
- FC
- DC
- TC
- VC
- FTS
- Dehydrator
- Contactor
- Energy Exchange Pump
- LC
- Reboiler
- Pressure Relief Valve
- Pneumatic Controller
- Compressor Seal
- Lubrication
- Gas Leakage
- Piston Rod
- Cylindrical Wall
- Packing Cup
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
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

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

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

\[ DF = \frac{i(1 + i)^n}{(1 + i)^n - 1} \]
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 m³/minute
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 m³/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
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
Component Count vs. Emissions

Distribution of component count and estimated emissions by screening range

## Is Recovery Profitable?

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

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 (H₂S) and CO₂ 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 CO₂ it is typically vented to the atmosphere, flared, or recovered for enhanced oil recovery (EOR)
  - H₂S 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®
AGR Alternatives: Membrane Separator

- Membrane separation of CO₂ from feed gas
- High CO₂ permeate (effluent or waste stream) exiting the membrane is vented or blended into fuel gas
- Low CO₂ product exiting the membrane exceeds pipeline spec and is blended with feed gas
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% CO₂
  - Expand with additional membranes
**AGR Alternatives: Molecular Gate®**

- Molecular Gate® adsorbs acid gas (CO₂ and H₂S) 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
## Comparison of AGR Alternatives

<table>
<thead>
<tr>
<th>Absorbent or Adsorbent</th>
<th>Amine (or Selexol™) Process</th>
<th>Kvaerner Membrane</th>
<th>Molecular Gate® CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water &amp; amine (Selexol™)</td>
<td>Cellulose acetate</td>
<td></td>
<td>Titanium silicate</td>
</tr>
</tbody>
</table>

| 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
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Recommended Technologies (Arabic)
epa.gov/gasstar/tools/arabic/index.html