Directed Inspection and Maintenance and Infrared Leak Detection Agenda

- Methane Losses
  - What are the sources of emissions?
  - How much methane is emitted?

- Methane Recovery
  - Directed Inspection and Maintenance (DI&M)
  - DI&M by Infrared Leak Detection

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

- Over 395,000 producing gas wells nationally
- Fugitive emissions from gas production and gathering/boosting facilities are estimated to be 25 billion cubic feet per year (Bcf/year)
- Estimated 63 thousand cubic feet emissions (Mcf) per well-year
  - Worth $441/well-yr

Source: Newfield
What is the Problem?

- Methane gas leaks are invisible, unregulated, and go unnoticed.

- Natural Gas STAR Partners find that valves, connectors, compressor seals, and open-ended lines (OELs) are major methane emission sources.

  - In 2005, 2.6 Bcf of methane was emitted as fugitives by reciprocating compressor related components alone.
  - Production fugitive methane emissions depend on operating practices, equipment age, and maintenance.
Sources of Methane Emissions
What are the losses? - Clearstone

- Clearstone studied 4 gas processing plants
  - Screened for all leaks
  - Measured larger leak rates
  - Analyzed data

- Principles are relevant to all sectors
  - Fugitive leaks from valves, connectors, compressor seals, and lines still a problem in production
  - Solution is the same
Distribution of Losses by Source Category

- Leaking Components: 53.1%
- Combustion Equipment: 9.9%
- Amine Vents: 0.5%
- Flare Systems: 24.4%
- Non-leaking Components: 0.1%
- NRU Vents: 0.3%
- Storage Tanks: 11.8%

Source: Clearstone Engineering, 2002
Distribution of Losses from Equipment Leaks by Type of Component

- Control Valves: 4.0%
- Orifice Meters: 0.1%
- Pressure Relief Valves: 3.5%
- Open-Ended Lines: 11.1%
- Other Flow Meters: 0.2%
- Valves: 26.0%
- Compressor Seals: 23.4%
- Crankcase Vents: 4.2%
- Connectors: 24.4%
- Blowdowns: 0.8%
- Pump Seals: 1.9%
- Pressure Regulators: 0.4%

Source: Clearstone Engineering, 2002
How Much Methane is Emitted?

Methane Emissions from Leaking Components at Gas Processing Plants

<table>
<thead>
<tr>
<th>Component Type</th>
<th>% of Total Methane Emissions</th>
<th>% Leak Sources</th>
<th>Estimated Average Methane Emissions per Leaking Component (Mcf/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves (Block &amp; Control)</td>
<td>26.0%</td>
<td>7.4%</td>
<td>66</td>
</tr>
<tr>
<td>Connectors</td>
<td>24.4%</td>
<td>1.2%</td>
<td>80</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>23.4%</td>
<td>81.1%</td>
<td>372</td>
</tr>
<tr>
<td>Open-ended Lines</td>
<td>11.1%</td>
<td>10.0%</td>
<td>186</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>3.5%</td>
<td>2.9%</td>
<td>844</td>
</tr>
</tbody>
</table>


Mcf = Thousand cubic feet
# How Much Methane is Emitted?

## Summary of Natural Gas Losses from the Top Ten Leak Sources

<table>
<thead>
<tr>
<th>Plant Number</th>
<th>Gas Losses From Top 10 Leak Sources (Mcf/day)</th>
<th>Gas Losses From All Leak Sources (Mcf/day)</th>
<th>Contribution By Top 10 Leak Sources (%)</th>
<th>Contribution By Total Leak Sources (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>43.8</td>
<td>122.5</td>
<td>35.7</td>
<td>1.78</td>
</tr>
<tr>
<td>2</td>
<td>133.4</td>
<td>206.5</td>
<td>64.6</td>
<td>2.32</td>
</tr>
<tr>
<td>3</td>
<td>224.1</td>
<td>352.5</td>
<td>63.6</td>
<td>1.66</td>
</tr>
<tr>
<td>4</td>
<td>76.5</td>
<td>211.3</td>
<td>36.2</td>
<td>1.75</td>
</tr>
<tr>
<td>Combined</td>
<td>477.8</td>
<td>892.8</td>
<td>53.5</td>
<td>1.85</td>
</tr>
</tbody>
</table>

1 – Excluding leakage into flare system
Methane Recovery

- Fugitive losses can be dramatically reduced by implementing a directed inspection and maintenance program
  - Voluntary program to identify and fix leaks that are cost-effective to repair
  - Survey cost will pay out in the first year
  - Provides valuable data on leak sources with information on where to look “next time”
What is Directed Inspection and Maintenance?

- Directed Inspection and Maintenance (DI&M)
  - Cost-effective practice, by definition
  - Find and fix significant leaks
  - Choice of leak detection technologies
  - Strictly tailored to company’s needs
- DI&M is NOT the regulated volatile organic compound leak detection and repair (VOC LDAR) program

Source: Targa Resources
How Do You Implement DI&M?

1. CONDUCT baseline survey
2. SCREEN and MEASURE leaks
3. FIX on the spot leaks
4. ESTIMATE repair cost, fix to a payback criteria
5. DEVELOP a plan for future DI&M
6. RECORD savings/REPORT to Natural Gas STAR
How Do You Implement DI&M?

- Screening - find the leaks
  - Soap bubble screening
  - Electronic screening ("sniffer")
  - Toxic vapor analyzer (TVA)
  - Organic vapor analyzer (OVA)
  - Ultrasound leak detection
  - Acoustic leak detection
  - Infrared leak detection
How Do You Implement DI&M?

- Evaluate the leaks detected - measure results
  - High volume sampler
  - Toxic vapor analyzer (correlation factors)
  - Rotameters
  - Calibrated bagging
# How Do You Implement DI&M?

## Summary of Screening and Measurement Techniques

<table>
<thead>
<tr>
<th>Instrument/ Technique</th>
<th>Effectiveness</th>
<th>Approximate Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soap Solution</td>
<td>★★</td>
<td>$</td>
</tr>
<tr>
<td>Electronic Gas Detector</td>
<td>★</td>
<td>$$</td>
</tr>
<tr>
<td>Acoustic Detector/ Ultrasound Detector</td>
<td>★★</td>
<td>$$$</td>
</tr>
<tr>
<td>TVA (Flame Ionization Detector)</td>
<td>★</td>
<td>$$$</td>
</tr>
<tr>
<td>Calibrated Bagging</td>
<td>★</td>
<td>$$</td>
</tr>
<tr>
<td>High Volume Sampler</td>
<td>★★★</td>
<td>$$$</td>
</tr>
<tr>
<td>Rotameter</td>
<td>★★</td>
<td>$$</td>
</tr>
<tr>
<td>Infrared Leak Detection</td>
<td>★★★</td>
<td>$$$</td>
</tr>
</tbody>
</table>

* Source: EPA’s Lessons Learned

* - Least effective at screening/measurement

$ - Smallest capital cost

*** - Most effective at screening/measurement

$$ - Largest capital cost
Estimating Comprehensive Survey Cost

- Cost of complete screening survey using high volume sampler (processing plant)
  - Ranges $15,000 to $20,000 per medium size plant
  - Rule of Thumb: $1 per component for an average processing plant
  - Cost per component for remote production sites would be higher than $1
- 25 to 40% cost reduction for follow-up survey
  - Focus on higher probability leak sources (e.g. compressors)
DI&M by Infrared Leak Detection

- Real-time detection of methane leaks
- Quicker identification & repair of leaks
- Screen hundreds of components an hour
- Screen inaccessible areas simply by viewing them

Source: Leak Surveys Inc.
Infrared Methane Leak Detection

Video recording of fugitive leaks detected by various infrared devices
## Is Recovery Profitable?

<table>
<thead>
<tr>
<th>Component</th>
<th>Value of lost gas(^1) ($)</th>
<th>Estimated repair cost ($)</th>
<th>Payback (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug Valve: Valve Body</td>
<td>29,498</td>
<td>200</td>
<td>0.1</td>
</tr>
<tr>
<td>Union: Fuel Gas Line</td>
<td>28,364</td>
<td>100</td>
<td>0.1</td>
</tr>
<tr>
<td>Threaded Connection</td>
<td>24,374</td>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>Distance Piece: Rod Packing</td>
<td>17,850</td>
<td>2,000</td>
<td>1.4</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>16,240</td>
<td>60</td>
<td>0.1</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>13,496</td>
<td>2,000</td>
<td>1.8</td>
</tr>
<tr>
<td>Gate Valve</td>
<td>11,032</td>
<td>60</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Source: Hydrocarbon Processing, May 2002

\(^1\) – Based on $7/Mcf gas price
DI&M - Lessons Learned

- A successful, cost-effective DI&M program requires measurement of the leaks.
- A high volume sampler is an effective tool for quantifying leaks and identifying cost-effective repairs.
- Open-ended lines, compressor seals, blowdown valves, engine-starters, and pressure relief valves represent <3% of components but >60% of methane emissions.
- The business of leak detection has changed dramatically with new technology.

Source: Chevron
Partner Experience - Targa Resources (formerly Dynegy)

- Surveyed components in two processing plants: 23,169 components
- Identified leaking components: 857 about 3.6%
- Repaired components: 80 to 90% of the identified leaking components
- Annual methane emissions reductions: 198,000 Mcf/year
- Annual savings: $1,386,000/year (at $7/Mcf)

Source: Targa Resources
Discussion

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