Directed Inspection and Maintenance and Infrared Leak Detection

Lessons Learned from Natural Gas STAR

Occidental Petroleum Corporation and California Independent Petroleum Association

Producers Technology Transfer Workshop
Long Beach, California
August 21, 2007

epa.gov/gasstar
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 500,000 producing oil wells nationally
- Fugitive emissions from oil production wells and facilities are estimated to be 2.4 billion cubic feet per year (Bcf/year)
- Worth $16.8 million at today’s gas prices

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, 1.1 Bcf of methane was emitted as fugitives by well heads and related components alone.
  - Production fugitive methane emissions depend on operating practices, equipment age, and maintenance.
Sources of Methane Emissions

FTS = flash tank separator
What are the losses? - Clearstone

- Clearstone studied four 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%
- Flare Systems: 24.4%
- Non-leaking Components: 0.1%
- NRU Vents: 0.3%
- Storage Tanks: 11.8%
- Amine Vents: 0.5%

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

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

<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
## 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><strong>Combined</strong></td>
<td><strong>477.8</strong></td>
<td><strong>892.8</strong></td>
<td><strong>53.5</strong></td>
<td><strong>1.85</strong></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?

<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
Economic Analysis of DI&M of OELs

<table>
<thead>
<tr>
<th>Economic Analysis of DI&amp;M of Open-Ended Lines at Large and Small Gas Plants(^1)</th>
<th>Small</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Plants OELs (Man-day/year)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inspection of Booster OELs (Man-day/year)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Inspection Prep and Record (Man-day/year)</td>
<td>NA</td>
<td>3</td>
</tr>
<tr>
<td>Repairs &amp; Maintenance (Man-days)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Labor Cost ($/day)</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Total Labor Cost ($/year)</td>
<td>2,000</td>
<td>4,500</td>
</tr>
<tr>
<td>Methane Savings (Mcf/year)</td>
<td>3,319</td>
<td>4,526</td>
</tr>
<tr>
<td>Gas Savings (Mcf/year)(^2)</td>
<td>3,688</td>
<td>5,029</td>
</tr>
<tr>
<td>Gas Saving Value ($/year)</td>
<td>25,816</td>
<td>35,203</td>
</tr>
<tr>
<td>Payback (year)</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

1 – Based on data presented by Targa Resources on July 26, 2006. Assumes two inspections per year
2 – Gas values based on $7/Mcf
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
Partner Experience - Chevron

- Chunchula, Alabama gas processing plant
  - Plant processes 37.5 MMcf/day
  - Survey conducted April 4 to 9, 2005
- Screening equipment
  - Soaping solution, sniffers, infrared camera
- Quantification
  - High volume sampler
  - 17,000 components screened
  - 224 components (1.3%) were found to be leaking

Source: Chevron
Discussion

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