Directed Inspection and Maintenance and IR Leak Detection

Lessons Learned from Natural Gas STAR

Producers and Processors Technology Transfer Workshop
ConocoPhillips and EPA’s Natural Gas STAR Program
Kenai, AK
May 25, 2006

Directed Inspection and Maintenance (DI&M): Agenda
- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions
Methane Losses by Equipment Type

Source: Clearstone Engineering, 2002

What is the Problem?

- Gas leaks are *invisible, unregulated* and go *unnoticed*
- Gas STAR Partners find that valves, connectors, compressor seals and open-ended lines (OELs) are major sources
  - 27 Bcf of methane emitted per year by reciprocating compressors seals and OELs, each contributing equally to the emissions
What are the Sources of Emissions?

How Much Methane is Emitted?

<table>
<thead>
<tr>
<th>Component Type</th>
<th>% of Total Methane Emissions</th>
<th>% Leaks</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>Open-Ended Lines</td>
<td>11.1%</td>
<td>8.1%</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>

How Much Methane is Emitted?

A total of 101,193 components were screened at four processing plants.

<table>
<thead>
<tr>
<th>Plant No.</th>
<th>Gas Losses From Top 10 Leakers (Mcfd)</th>
<th>Gas Losses From All Equipment Leakers (Mcfd)</th>
<th>Contribution By Top 10 Leakers (%)</th>
<th>Contribution By Total Leakers (%)</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>892.84</td>
<td>53.5</td>
<td>1.85</td>
</tr>
</tbody>
</table>

1Excluding leakage into flare system

Methane Recovery

Fugitive losses can be dramatically reduced by implementing a DI&M 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 leakers with information of where to look
What is DI&M?

- Direct Inspection and Maintenance
  - 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 (VOC) leak detection and repair program (LDAR)

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 Gas STAR
Screening and Measurement

<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 Detectors</td>
<td>*</td>
<td>$$</td>
</tr>
<tr>
<td>Acoustic Detection/ Ultrasound Detection</td>
<td>**</td>
<td>$$$</td>
</tr>
<tr>
<td>TVA (FID)</td>
<td>*</td>
<td>$$$</td>
</tr>
<tr>
<td>Bagging</td>
<td>*</td>
<td>$$$</td>
</tr>
<tr>
<td>High Volume Sampler</td>
<td>** **</td>
<td>$$$</td>
</tr>
<tr>
<td>Rotameter</td>
<td>**</td>
<td>$</td>
</tr>
<tr>
<td>Infrared Detection</td>
<td>** **</td>
<td>$$$</td>
</tr>
</tbody>
</table>

* - Least effective at screening/measurement
** - Most effective at screening/measurement
$ - Smallest capital cost
$$ - Largest capital cost

How Do You Implement DI&M?

- Evaluate the leaks detected - measure results
  - High Volume Sampler
  - Toxic Vapor Analyzer (correlation factors)
  - Rotameters
  - Calibrated bag
Is Recovery Profitable?

### Repair the Cost Effective Components

<table>
<thead>
<tr>
<th>Component</th>
<th>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>29,496</td>
<td>200</td>
<td>0.1</td>
</tr>
<tr>
<td>Union: Fuel Gas Line</td>
<td>28,362</td>
<td>100</td>
<td>0.0</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>17,847</td>
<td>2,000</td>
<td>1.4</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>16,238</td>
<td>60</td>
<td>0.0</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>13,493</td>
<td>2,000</td>
<td>1.8</td>
</tr>
<tr>
<td>Gate Valve</td>
<td>11,034</td>
<td>60</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1Based 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, engine-starter and pressure relief valves represent <3% of components but >60% of methane emissions
- The business of leak detection is changing dramatically with new technology
DI&M - Partner Experience

Partner A: Leaking cylinder head was tightened, which reduced the methane emissions from almost 64,000 Mcf/yr to 3,300 Mcf/yr
- Repair required 9 man-hours of labor
- Gas savings were approximately 60,700 Mcf/yr
- Value of gas saved was $424,900/year at $7/Mcf

Partner B: One-inch pressure relief valve emitted almost 36,774 Mcf/yr
- Required five man-hours of labor and $125 of materials
- Value of the gas saved was $257,400 at $7/Mcf

Discussion Questions

- To what extent are you implementing these opportunities?
- How could these opportunities be improved upon or altered for use in your operation?
- Can you suggest other methods for reducing emissions from leaking components?
- What are the barriers (technological, economic, lack of information, manpower, etc.) that are preventing you from implementing these practices?