Reducing Methane Emissions through Directed Inspection and Maintenance (DI&M)

Oil & Gas Subcommittee Technology Transfer Workshop

January 28, 2009
Monterrey, Mexico
Directed Inspection and Maintenance and Infrared Leak Detection Agenda

- What are fugitive equipment leaks?
- What is DI&M
- Infrared Leak Detection
- Partner Experience
- Discussion
Key Characteristics of Fugitive Equipment Leaks

- Fugitive equipment leaks are a major source of CH$_4$ emissions at oil and gas facilities.
- Most of these emissions are from a few big leaks rather than many small or medium sized leaks.
- 75 to 85% of the emissions from leaks are cost effective to fix (often payback of <6 months).
- Components in gas service leak more than those in liquid service.
- Components in sweet service more likely to leak than those in sour or odorized service.
- Leak potential tends to increase with time and usage.
- Different types of components and service applications have different leak potentials (i.e., leak magnitude and probability).
- Components in vibration, cryogenic or thermal cycling service have an increased leak potential.
Why Do Big Leaks Occur?

- Big leaks often go unnoticed because they occur in difficult-to-access, low-traffic, congested or noisy areas, or the amount of leakage is not fully appreciated.

- Big leaks may also occur because of severe/demanding applications or the high cost or difficulty of repairs.
Methane Emissions at 76 Gas Production Facilities

Source: Clearstone Engineering
Distribution of Losses by Type of Component (Processing)

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

Source: Clearstone Engineering, 2002
Measured Leakages in Compressor Stations

Source: Clearstone Engineering, 2002
What is Normal Leak Control Practice?

- Perform a leak check (using a bubble test or hand-held gas sensor) on equipment components when first installed, and after inspection & maintenance.

- Thereafter, leaks are detected by:
  - Area or building monitors.
  - Personal monitors.
  - Olfactory, audible or visual indicators.

-Leaks only fixed if this is easy to do or they pose an obvious safety concern.

- Unmanned facilities get less attention than manned facilities.

- Priority following a facility turnaround is to get it back on line rather than ensure all affected components have been leak checked.
What is Directed Inspection & Maintenance (DI&M)?

It is a practicable ongoing approach to achieving significant cost-effective reductions in fugitive equipment leaks:

- Find the big leaks in an efficient manner:
  - Focus efforts on the most likely sources of big leaks with coarse or less frequent screening of other components.
- Only repair components that are cost-effective to repair or pose a safety or environmental concern.
- Minimize the potential for big leaks and provide early detection and repair of these when they occur.
What are the benefits of DI&M?

- Attractive payback (often <6 months).
- Reduced maintenance costs.
- Reduced downtime.
- Improved process efficiency.
- Safer work environment.
- Cleaner environment.
- Resource conservation.
### Where Should Leak Monitoring Efforts Be Focused?

**Table 1. Sample leak statistics for gas transmission facilities.**

<table>
<thead>
<tr>
<th>Source</th>
<th>Number of Sources</th>
<th>Leak Frequency</th>
<th>Average Emissions (lb/h/source)</th>
<th>Percent of Component Population</th>
<th>Contribution to Total Emissions (%)</th>
<th>Relative Leak Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station or Pressurized Blowdown System</td>
<td>219</td>
<td>59.8</td>
<td>7.50E+00</td>
<td>0.131</td>
<td>53.170</td>
<td>7,616.00</td>
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<tr>
<td>Compressor Seal – Centrifugal</td>
<td>103</td>
<td>64.1</td>
<td>2.79E+00</td>
<td>0.061</td>
<td>9.313</td>
<td>2,838.00</td>
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<tr>
<td>Compressor Seal – Reciprocating</td>
<td>167</td>
<td>40.1</td>
<td>2.35E+00</td>
<td>0.099</td>
<td>12.722</td>
<td>2,400.00</td>
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<tr>
<td>Pressure Relief Valve</td>
<td>612</td>
<td>31.2</td>
<td>3.56E-01</td>
<td>0.366</td>
<td>7.058</td>
<td>362.00</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>928</td>
<td>58.1</td>
<td>2.02E-01</td>
<td>0.555</td>
<td>6.065</td>
<td>205.00</td>
</tr>
<tr>
<td>Orifice Meter</td>
<td>185</td>
<td>22.7</td>
<td>1.07E-01</td>
<td>0.110</td>
<td>0.640</td>
<td>109.00</td>
</tr>
<tr>
<td>Control Valve</td>
<td>782</td>
<td>9.0</td>
<td>3.63E-02</td>
<td>0.467</td>
<td>0.918</td>
<td>37.00</td>
</tr>
<tr>
<td>Pressure Regulator</td>
<td>816</td>
<td>7.0</td>
<td>1.75E-02</td>
<td>0.488</td>
<td>0.461</td>
<td>18.00</td>
</tr>
<tr>
<td>Valve</td>
<td>17,029</td>
<td>2.8</td>
<td>9.09E-03</td>
<td>10.190</td>
<td>5.007</td>
<td>9.00</td>
</tr>
<tr>
<td>Connector</td>
<td>145,829</td>
<td>0.9</td>
<td>9.83E-04</td>
<td>87.263</td>
<td>4.641</td>
<td>1.00</td>
</tr>
<tr>
<td>Other Flow Meter</td>
<td>443</td>
<td>1.8</td>
<td>2.19E-05</td>
<td>0.265</td>
<td>0.0003</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Source: Clearstone Engineering, 2007
# How Frequently Should Components Be Monitored?

The table below presents the suggested leak monitoring frequencies for equipment components, categorized by component category and type. The monitoring frequencies are given for all services and applications, with specific frequencies for each type of component.

<table>
<thead>
<tr>
<th>Source Category</th>
<th>Type of Component</th>
<th>Service</th>
<th>Application</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Equipment</td>
<td>Connectors and Covers</td>
<td>All</td>
<td>All</td>
<td>Immediately after any adjustments and once every 5 years thereafter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thermal Cycling</td>
<td>Bi-annually</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vibration</td>
<td>Annually</td>
</tr>
<tr>
<td>Control Valves</td>
<td>Gas/Vapour/LPG</td>
<td>All</td>
<td>All</td>
<td>Bi-annually</td>
</tr>
<tr>
<td></td>
<td>Gas/Vapour/LPG</td>
<td></td>
<td>Thermal Cycling</td>
<td>Bi-annually</td>
</tr>
<tr>
<td>Block Valves – Rising Stem</td>
<td>Gas/Vapour/LPG</td>
<td>All</td>
<td>All</td>
<td>Annually</td>
</tr>
<tr>
<td>Block Valves – Quarter Turn</td>
<td>Gas/Vapour/LPG</td>
<td>All</td>
<td>All</td>
<td>Once every 5 years</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Monthly</td>
</tr>
<tr>
<td>Pump Seals</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Annually</td>
</tr>
<tr>
<td>Open-ended Lines</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Annually</td>
</tr>
<tr>
<td>Emergency Vent and Blowdown Systems</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Vapour Collection Systems</td>
<td>Tank Hatches</td>
<td>All</td>
<td>All</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Pressure-Vacuum Safety Valves</td>
<td>All</td>
<td>All</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

Source: Clearstone Engineering, 2006
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
  - End-of-pipe technologies
    - Velocity traverse
    - Rotameters
    - Calibrated bagging
  - Toxic vapor analyzer (correlation factors)
### 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>$$$</td>
</tr>
<tr>
<td>End-of-pipe Flow Measurement</td>
<td>★ ★</td>
<td>$$</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
*** - Most effective at screening/measurement
$ - Smallest capital cost
$$ - Largest capital cost
Estimating Comprehensive Leak Survey Costs

- Cost of complete screening survey using high volume sampler (processing plant)
  - Ranges US$15,000 to US$20,000 per medium-size plant
  - Rule of Thumb: US$1 per component for an average processing plant
  - Cost per component for remote production sites would be higher than US$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 of leaks.
- Screen hundreds of components an hour.
- Screen inaccessible areas simply by viewing them.
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) (US$)</th>
<th>Estimated repair cost (US$)</th>
<th>Payback (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug Valve: Valve Body</td>
<td>21,070</td>
<td>200</td>
<td>0.11</td>
</tr>
<tr>
<td>Union: Fuel Gas Line</td>
<td>20,260</td>
<td>100</td>
<td>0.06</td>
</tr>
<tr>
<td>Threaded Connection</td>
<td>17,410</td>
<td>10</td>
<td>0.01</td>
</tr>
<tr>
<td>Distance Piece: Rod Packing</td>
<td>12,750</td>
<td>2,000</td>
<td>1.88</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>11,600</td>
<td>60</td>
<td>0.06</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>9,640</td>
<td>2,000</td>
<td>2.49</td>
</tr>
<tr>
<td>Gate Valve</td>
<td>7,880</td>
<td>60</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Source: Hydrocarbon Processing, May 2002 (Repair cost)

\(^1\) Adjusted to US$5/MMBtu 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
Discussion

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