Directed Inspection & Maintenance
Methane to Markets Partnership Workshop
Technology Transfer Workshop

October 4, 2010, Moscow, Russia
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Leak Characteristics

- Contribute significantly to total CH$_4$ emissions at natural gas facilities.

- Only a few percent of the components actually leak.

- Most of the leakage is usually from just a few big leakers.

- Different types of components have different leak potentials and wear out at different rates.

- Components in sour or odorized service tend to leak less than those in sweet or unodorized service.
Fugitive Emissions

- Distribution of opportunities is skewed
- Few sources are responsible for majority of emissions—focus efforts on these sources first

![Graph showing leakage (MMcf/yr) by Compressor Stations]

Leakage (MMcf/yr)

Compressor Stations
Opportunities are Greatest at Older Facilities: Average Emissions vs Age
Reasons for Big Leaks

- Flaws, improper installation, damage, and progressive deterioration.
- Severe/demanding applications coupled with high cost or difficulty of repairs.
- Lack of leak checks after maintenance activities.
- Unnoticed leaks because they occur in difficult-to-access, low-traffic, crowded or noisy areas.
- Lack of measurement data to build a business case.
What is Normal Practice?

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

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

-Leaks are fixed if it is easy to do or they pose a safety concern.

- Unmanned facilities get less attention than manned facilities.

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

- Fugitive losses can be reduced dramatically by implementing a systematic leak detection and repair program
- Natural Gas STAR refers to this practice as Directed Inspection and Maintenance (DI&M):
  - Practicable ongoing program to identify & fix leaks.
  - Focus efforts on the areas that offer the greatest opportunities.
  - Use the DI&M results to determine where best to look.
  - Only fix leaks that are cost-effective to repair or pose a safety, health or environmental risk.
  - Adapt to each company’s and facility’s needs and circumstances.
  - Utilizes various options for leak detection & quantification.
What are the Benefits?

- Resource conservation.
- Increased revenue.
- Cost-effective
- Improved system reliability.
  - Reduced downtime.
  - Potentially reduced maintenance costs through early detection of problems.
- Safer work place.
- Improved environmental performance.
- Best-in-Class recognition.
## Where Should Efforts be Focused?

### 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 (kg/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>Pressurized Station or Unit Blowdown System</td>
<td>219</td>
<td>59.8</td>
<td>3.41E+00</td>
<td>0.131</td>
<td>53.116</td>
<td>7616</td>
</tr>
<tr>
<td>Compressor Seal – Centrifugal</td>
<td>103</td>
<td>64.1</td>
<td>1.27E+00</td>
<td>0.062</td>
<td>9.310</td>
<td>2838</td>
</tr>
<tr>
<td>Compressor Seal – Reciprocating</td>
<td>167</td>
<td>40.1</td>
<td>1.07E+00</td>
<td>0.100</td>
<td>12.764</td>
<td>2400</td>
</tr>
<tr>
<td>Pressure Relief Valve</td>
<td>612</td>
<td>31.2</td>
<td>1.62E-01</td>
<td>0.366</td>
<td>7.062</td>
<td>362</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>928</td>
<td>58.1</td>
<td>9.18E-02</td>
<td>0.555</td>
<td>6.070</td>
<td>205</td>
</tr>
<tr>
<td>Orifice Meter</td>
<td>185</td>
<td>22.7</td>
<td>4.86E-02</td>
<td>0.111</td>
<td>0.641</td>
<td>109</td>
</tr>
<tr>
<td>Control Valve</td>
<td>782</td>
<td>9</td>
<td>1.65E-02</td>
<td>0.468</td>
<td>0.919</td>
<td>37</td>
</tr>
<tr>
<td>Pressure Regulator</td>
<td>816</td>
<td>7</td>
<td>7.95E-03</td>
<td>0.488</td>
<td>0.462</td>
<td>18</td>
</tr>
<tr>
<td>Valve</td>
<td>17029</td>
<td>2.8</td>
<td>4.13E-03</td>
<td>10.190</td>
<td>5.011</td>
<td>9</td>
</tr>
<tr>
<td>Connector</td>
<td>145829</td>
<td>0.9</td>
<td>4.47E-04</td>
<td>87.264</td>
<td>4.644</td>
<td>1</td>
</tr>
<tr>
<td>Other Flow Meter</td>
<td>443</td>
<td>1.8</td>
<td>9.94E-06</td>
<td>0.265</td>
<td>0.000</td>
<td>0.02</td>
</tr>
</tbody>
</table>
### Component Specific Suggested Leak Monitoring Frequencies

<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></td>
<td>Immediately after any adjustments and once every 5 years thereafter.</td>
</tr>
<tr>
<td></td>
<td>Control Valves</td>
<td>Gas/Vapour/LPG</td>
<td></td>
<td>Annually.</td>
</tr>
<tr>
<td></td>
<td>Block Valves – Rising Stem</td>
<td>Gas/Vapour/LPG</td>
<td>All</td>
<td>Annually.</td>
</tr>
<tr>
<td></td>
<td>Block Valves – Quarter Turn</td>
<td>Gas/Vapour/LPG</td>
<td>All</td>
<td>Once every 5 years.</td>
</tr>
<tr>
<td></td>
<td>Compressor Seals</td>
<td>All</td>
<td>All</td>
<td>Quarterly.</td>
</tr>
<tr>
<td></td>
<td>Pump Seals</td>
<td>All</td>
<td>All</td>
<td>Quarterly.</td>
</tr>
<tr>
<td></td>
<td>Pressure Relief Valves</td>
<td>All</td>
<td>All</td>
<td>Annually.</td>
</tr>
<tr>
<td></td>
<td>Open-ended Lines</td>
<td>All</td>
<td>All</td>
<td>Annually.</td>
</tr>
<tr>
<td></td>
<td>Emergency Vent and Blowdown Systems¹</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>Quarterly.</td>
</tr>
<tr>
<td></td>
<td>Pressure-Vacuum Safety Valves</td>
<td>All</td>
<td>All</td>
<td>Quarterly.</td>
</tr>
</tbody>
</table>
How Do You Detect the Leaks?

- 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/Imaging
How Do You Measure the Leaks?

- Evaluate the leaks detected - measure results
  - High Volume Sampler
  - TVA (correlation factors)
  - Rotameters
  - Calibrated Bag
  - Engineering Method
## 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>

* - Least effective at screening/measurement

$ - Smallest capital cost

*** - Most effective at screening/measurement

$$ - Largest capital cost
Example: Economic Analysis of DI&M at Compressor Stations

<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>

\(^1\) – Based on $7 per thousand cubic feet gas price

Source: “Cost-effective emissions reductions through leak detection, repair”. Hydrocarbon Processing, May 2002
Industry Experience – Targa Resources (U.S. Processing Company)

- Surveyed components in two processing plants: 23,169 components
- Identified leaking components: 857 (about 3.6%)
- Repaired 80 to 90% of the identified leaking components
- Annual methane emissions reductions: 5.6 million m³/year
- Annual savings: $1,386,000/year (at $250/thousand m³ or $7/Mcf)

Source: Targa Resources
Industry Experience – Kursk Natural Gas Distribution Company (Russian)

- Hired Heath Consultants to survey 47 regulator stations in November 2005
  - Surveyed 1,007 components
  - Found 94 leaks

- Using Hi Flow Sampler, quantified leaks as 900,000 m³ per year
  - Initial investment of $30,000
  - Produced revenue from verified carbon credits

- So successful, Kurskgas expanded study beyond initial 47 stations and covered over 3,300 components
Summary: 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.
- A relatively small number of large leaks cause most fugitive emissions.
- The business of leak detection is changing dramatically with new technology like infrared cameras that make DI&M faster and easier.
Other Innovative Leak Detection Approaches

- Greenhouse Gas Observing Satellite (GOSAT)
  - Joint project of JAXA (Japan Aerospace Exploration Agency), MOE (Ministry of the Environment) and NIES (National Institute for Environmental Studies)

- Observes concentrations of GHGs from orbit
  - Passive observation system
    - Calculates gas concentration using reflected light radiated by the sun that is absorbed by GHGs
    - Wide range of wavelengths (near infrared to thermal infrared)
  - Projected launch: early 2009
The concept of the natural gas pipeline leak detection system using GOSAT

Step-1: Satellite Pipeline leak observation
Step-2: Data transmission and analysis
Step-3: Ground exploration based on results of analysis
Step-4: Mitigation of problems

Spectrometer on GOSAT
- Polar Orbit (3 day repeat)
- 10km Resolution
- Detectable Limit: 1.3tCH₄/day

Step-1

Step-2

Step-3

Step-4

Leak Location
Mitigation & Improvement

Reduction of Greenhouse Gases
Prevention of Explosion
Wrap up

- Questions?
- Additional Information
  - [http://www.epa.gov/gasstar/tools/recommended.html](http://www.epa.gov/gasstar/tools/recommended.html)
- Thank you
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- dave.picard@clearstone.ca