Methane to Markets Experience with Methane Leak Detection and Measurement Technologies

Gazprom – EPA Technical Seminar on Methane Emission Mitigation

28 – 30 October, 2008
Methane Leak Detection and Measurement Technologies

- Systematic Leak Inspection and Repair Program (Directed Inspection and Maintenance)
  - Methane Emission Sources
  - Methane Recovery: Directed Inspection and Maintenance (DI&M)
  - DI&M with Infrared Leak Detection
  - Industry Experience
  - Summary: Lessons Learned

- Other Innovative Leak Detection Approaches

- Discussion

Source: TransCanada
Basis of Recommended Technologies and Practices

- All technologies and practices promoted by Methane to Markets and Natural Gas STAR are proven based on successful field implementation by Partner companies.

- Examples represented in the following presentation are based on company specific data collected from actual projects in the U.S. and other countries; economic information is presented according to U.S. costs and gas prices.
What is the Problem?

- Transmission methane gas leaks are *invisible, odorless*, and *go unnoticed*.
- Natural Gas STAR transmission and processing companies find that valves, connectors, compressor seals, and open-ended lines (OELs) are major methane fugitive emission sources.
  - Transmission fugitive methane emissions depend on operating practices, equipment age, and maintenance practices.
Overview: Methane Emission Sources
Leak Detection Study: Key Methane Emission Sources

- Study of 4 natural gas facilities provides insight into key methane sources
  - Screened for all leaks, measured larger leak rates

- Principles of study are relevant to all sectors
  - A relatively small number of large leaks cause most fugitive emissions
  - Fugitive leaks from valves, connectors, compressor seals, and open-ended lines are a large source of revenue loss for all sectors
  - Solution is the same

Source: Hy-bon

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Study Findings: Distribution of Methane Emissions by Source Category

- Equipment leaks are the largest emissions
  - Production & processing share some similar sources

Source: Clearstone Engineering, 2002
Study Findings: Distribution of Methane Emissions by Type of Component

- Distribution of leak sources similar in processing and transmission

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

Source: Clearstone Engineering, 2002
## Study Findings: Quantity of Methane Emitted

### Methane Emissions from Leaking Components at Gas Facilities

<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 (m³/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves (Block &amp; Control)</td>
<td>26.0%</td>
<td>7.4%</td>
<td>1,869</td>
</tr>
<tr>
<td>Connectors</td>
<td>24.4%</td>
<td>1.2%</td>
<td>2,265</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>23.4%</td>
<td>81.1%</td>
<td>10,534</td>
</tr>
<tr>
<td>Open-ended Lines</td>
<td>11.1%</td>
<td>10.0%</td>
<td>5,267</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>3.5%</td>
<td>2.9%</td>
<td>23,899</td>
</tr>
</tbody>
</table>

Source: Clearstone Engineering, 2002
## Study Findings: Quantity of Methane Emitted

<table>
<thead>
<tr>
<th>Facility</th>
<th>Gas Losses From Top 10 Leak Sources (m³/day)</th>
<th>Gas Losses From All Leak Sources (m³/day)</th>
<th>Contribution By Top 10 Leak Sources (%)</th>
<th>Contribution By Total Leak Sources (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1,240</td>
<td>3,469</td>
<td>35.7</td>
<td>1.78</td>
</tr>
<tr>
<td>B</td>
<td>3,777</td>
<td>5,847</td>
<td>64.6</td>
<td>2.32</td>
</tr>
<tr>
<td>C</td>
<td>6,346</td>
<td>9,982</td>
<td>63.6</td>
<td>1.66</td>
</tr>
<tr>
<td>D</td>
<td>2,166</td>
<td>5,983</td>
<td>36.2</td>
<td>1.75</td>
</tr>
<tr>
<td>Combined</td>
<td>13,530</td>
<td>25,281</td>
<td>53.5</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Source: Clearstone Engineering, 2002

1 – Excluding leakage into flare system
2 – Approximately 10,000 components tested in each facility
Methane Recovery: Directed Inspection & Maintenance (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)
  - Program to identify and fix leaks that are cost effective to repair
  - Many options for leak detection technologies
  - Provides valuable data on sources of leaks with information on where to look
  - Strictly adapted to company’s needs
  - Cost-effective practice, by definition
How Do You Implement DI&M?

- CONDUCT baseline survey
- SCREEN and MEASURE leaks
- FIX on the spot leaks
- ESTIMATE repair cost, fix to a payback criteria
- DEVELOP a plan for future DI&M
- RECORD savings
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

Leak Measurement Using High Volume Sampler
### 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
*** - Most effective at screening/measurement
$ - Smallest capital cost
$$ - Largest capital cost
Additional Gas Vent Measurement Tools

- **GRI-GLYCalc**
  - Software tool that uses field conditions and compositional data to simulate hydrocarbon emissions from glycol dehydrators
  - Factors in flash gas control technologies into emissions estimate

- **Vasquez-Beggs**
  - Estimate methane emissions from oil and condensate tanks

**Vasquez-Beggs Equation**

\[
\text{GOR} = A \times (G_{\text{flash gas}}) \times (P_{\text{sep}} + 14.7)^{B} \times \exp\left(\frac{C \times G_{\text{oil}}}{T_{\text{sep}} + 460}\right)
\]

where,

- \(\text{GOR}\) = Ratio of flash gas production to standard stock tank barrels of oil produced, in scf/bbl oil (barrels of oil corrected to 60°F)
- \(G_{\text{flash gas}}\) = Specific gravity of the tank flash gas, where \(a = 1\). A suggested default value for \(G_{\text{flash gas}}\) is 1.22 (TNRCC; Vasquez, 1980)
- \(G_{\text{oil}}\) = API gravity of stock tank oil at 60°F
- \(P_{\text{sep}}\) = Pressure in separator, in psig
- \(T_{\text{sep}}\) = Temperature in separator, °F

For \(G_{\text{oil}} \leq 30°\text{API}: A = 0.0362; B = 1.0937; \) and \(C = 25.724\)

For \(G_{\text{oil}} > 30°\text{API}: A = 0.0178; B = 1.187; \) and \(C = 23.931\)

- psig – pounds per square inch, gauge
- scf – standard cubic feet
- bbl – barrels
DI&M with Infrared Leak Detection

- The challenge has always been finding those few large leaks among the hundreds of components
- Real-time detection of gas leaks
  - Quicker identification and repair of leaks
  - Screen hundreds of components an hour
  - Easily screen inaccessible areas
Remote Sensing and Leak Detection Video

- Techniques to find fugitive leaks with new technology and equipment

5 minutes
Available for download at www.epa.gov/gasstar
### Example: Economic Analysis of DI&M at Compressor Stations

#### 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>29,498</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 m^3/year
- Annual savings: $1,386,000/year (at $250/thousand m^3 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: Leak Location
Step-2: Mitigation & Improvement

Reduction of Greenhouse Gases
Prevention of Explosion
Discussion Questions

- To what extent are you implementing these opportunities?
- How could these opportunities be improved upon or altered for use in your operation?
- Do you use any additional methods?
- What are the barriers (technological, economic, lack of information, labor, etc.) that are preventing you from implementing these practices?