DI&M (Directed Inspection & Maintenance), A Gas STAR International Best Practice

1st Asia Pacific Global Methane Initiative Oil & Gas Sector Workshop

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ICF International
Agenda

- What is the Problem?
- Methane Losses
  - Sources of methane emissions
  - What are the losses?—Clearstone
- Methane Recovery
  - What is Directed Inspection and Maintenance (DI&M)?
  - How do you implement DI&M?
- Estimating Comprehensive Survey Cost
- Is Recovery Profitable?
- Contacts and Further Information
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 fugitive emission sources
  - In 2007, 104.5 million cubic meters (MMcm) of methane was emitted as fugitives by reciprocating compressor related components alone
  - Production and processing fugitive methane emissions depend on operating practices, equipment age, and maintenance
Sources of Methane Emissions
What are the losses?—Clearstone

- Clearstone studied 4 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

Source: Hy-bon Engineering
Distribution of Losses by Source Category

- Leaking Components: 53.1%
- Combustion Equipment: 9.9%
- Amine Vents: 0.5%
- Flare Systems: 24.4%
- Non-leaking Components: 0.1%
- NRU Vents: 0.3%
- Storage Tanks: 11.8%

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

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

Source: Clearstone Engineering, 2002
# Fugitive Equipment Leaks

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Number of Components surveyed Per Site</th>
<th>Leak Frequency (%)</th>
<th>Emissions From All Leaking Sources</th>
<th>Combustion to THC Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Methane (tonnes/year)</td>
<td>Value ($/year)</td>
</tr>
<tr>
<td>Gas Plants</td>
<td></td>
<td></td>
<td>(tonnes/year)</td>
<td>($/year)</td>
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<tr>
<td>56461</td>
<td>1.7</td>
<td>997</td>
<td>500253</td>
<td>35</td>
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<td>16050</td>
<td>3.5</td>
<td>471</td>
<td>320606</td>
<td>36</td>
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<td>14424</td>
<td>3.0</td>
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<td>558663</td>
<td>64</td>
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<td>14174</td>
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<td>553248</td>
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<td>11556</td>
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<td>621061</td>
<td>33</td>
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<td>386533</td>
<td>57</td>
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<td>13471</td>
<td>1.2</td>
<td>299</td>
<td>178744</td>
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<tr>
<td>3672</td>
<td>10.3</td>
<td>2334</td>
<td>1262874</td>
<td>77</td>
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<td>5979</td>
<td>0.6</td>
<td>29</td>
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<td>93</td>
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<td><strong>TOTAL</strong></td>
<td><strong>148920</strong></td>
<td><strong>8320</strong></td>
<td><strong>4393854</strong></td>
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<td><strong>AVERAGE</strong></td>
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<td><strong>924</strong></td>
<td><strong>488206</strong></td>
<td><strong>54</strong></td>
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<tr>
<td>Compressor Stations</td>
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<td></td>
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<tr>
<td>608</td>
<td>5.1</td>
<td>110</td>
<td>61572</td>
<td>90</td>
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<tr>
<td>4626</td>
<td>1.1</td>
<td>98</td>
<td>49184</td>
<td>83</td>
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<td>3084</td>
<td>0.7</td>
<td>169</td>
<td>98802</td>
<td>95</td>
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<td>6168</td>
<td>1.0</td>
<td>194</td>
<td>103509</td>
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<td>1568</td>
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<td>224</td>
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<td>0</td>
<td>189</td>
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<td>1.9</td>
<td>4</td>
<td>2367</td>
<td>88</td>
</tr>
<tr>
<td>2115</td>
<td>1.8</td>
<td>67</td>
<td>27853</td>
<td>89</td>
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<td>2516</td>
<td>1.1</td>
<td>45</td>
<td>18901</td>
<td>91</td>
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<td><strong>TOTAL</strong></td>
<td><strong>22300</strong></td>
<td><strong>767</strong></td>
<td><strong>395926</strong></td>
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<tr>
<td><strong>AVERAGE</strong></td>
<td><strong>2478</strong></td>
<td><strong>85</strong></td>
<td><strong>43992</strong></td>
<td><strong>83</strong></td>
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<tr>
<td>Well Sites</td>
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<td></td>
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<tr>
<td>1474</td>
<td>0.2</td>
<td>1</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>1617</td>
<td>1.5</td>
<td>1</td>
<td>35</td>
<td>88</td>
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<tr>
<td>1797</td>
<td>0.4</td>
<td>1</td>
<td>58</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4888</strong></td>
<td><strong>3</strong></td>
<td><strong>1437</strong></td>
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<tr>
<td><strong>AVERAGE</strong></td>
<td><strong>407</strong></td>
<td><strong>0.7</strong></td>
<td><strong>120</strong></td>
<td><strong>97</strong></td>
</tr>
</tbody>
</table>

- Value of emissions based on natural gas price of $6.78/GJ
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

Source: Targa Resources
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 (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>Station or Pressurized 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>
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<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>
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<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>

Source: Clearstone Engineering, 2007
How Do You Implement DI&M?

- CONDUCT baseline survey
- SCREEN and MEASURE leaks
- FIX leaks on the spot
- ESTIMATE repair cost, FIX to a payback criteria
- DEVELOP a plan for future DI&M
- SHARE savings/success stories with Natural Gas STAR International
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?—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.
Source: Heath Consultants
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
★★★ - Most effective at screening/measurement
$ - Smallest capital cost
★★★ - 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)
Aerial leak surveys with infrared leak detection devices can aid in leak identification over large sections of pipelines.

Aerial surveys can be conducted in helicopters or fixed wing aircrafts using both active and passive IR detection devices.

Source: LaSen Inc.
Source: ANGEL, Aerial image
Aerial Pipeline Surveys

- Over 10 times faster than ground surveys
- Full coverage of the right-of-way
- Easy access to rough terrain and non-disruptive to private land owners

- Infrared Laser Beam
- Sniffer Detection

Atmosphere
Methane
Reflected Signal
Underground Pipeline
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
Contacts and Further Information

- More detail is available on these practices and over 80 others online at: [epa.gov/gasstar/tools/recommended.html](http://epa.gov/gasstar/tools/recommended.html)
- For further assistance, direct questions to:

  Scott Bartos  
  EPA Natural Gas STAR Program  
  bartos.scott@epa.gov  
  +1 (202) 343-9167

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  ICF International  
  drobinson@icfi.com  
  +1 (703) 218-2512
Following Presentations on Leak Detection

- “Leak Detection Practices & Demonstration of Optical Imaging”
  Milton Heath III
  Heath Consultants
  Manager Professional Services Division

- “Leak Detection Practices via FLIR Optical Imaging”
  Raymond Lau
  FLIR Systems Co. Ltd.
  Area Manager – ASEA