Directed Inspection and Maintenance and IR Leak Detection

Lessons Learned from Natural Gas STAR

Producers and Processors Technology Transfer Workshop

Western Gas Resources and EPA’s Natural Gas STAR Program Gillette and Rock Springs, WY May 9 & 11, 2006

Directed Inspection and Maintenance (DI&M): Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions
Natural Gas Industry Emissions

- Production and Processing sectors responsible for over half of the natural gas industry emissions

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emissions (Bcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>148</td>
</tr>
<tr>
<td>Processing</td>
<td>36</td>
</tr>
<tr>
<td>Distribution</td>
<td>68</td>
</tr>
<tr>
<td>Transmission &amp; Storage</td>
<td>101</td>
</tr>
<tr>
<td>Oil Downstream</td>
<td>2</td>
</tr>
<tr>
<td>Inventory</td>
<td>101</td>
</tr>
</tbody>
</table>

Methane Losses by Equipment Type

- 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%
- Valve's: 26.0%
- Blowdowns: 0.8%
- Connectors: 24.4%

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
How Much Methane is Emitted?

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

### Summary of Natural Gas Losses from the Top Ten Leakers\(^1\)

<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>

\(^1\)Excluding 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?

- 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/REPORT to Gas STAR

How Do You Implement DI&M?

- Screening - finding leaks
  - Soap bubble screening
  - Electronic screening (sniffer)
  - Toxic Vapor Analyzer (TVA)
  - Organic Vapor Analyzer (OVA)
  - Ultrasound Leak Detection
  - Acoustic Leak Detection
  - Optical Leak Imaging
How Do You Implement DI&M?

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

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
$$$ - Largest capital cost

* * * - Most effective at screening/measurement
$$ - Smallest capital cost
**DI&M by Leak Imaging**

- Real-time visual image of gas leaks
- Quicker identification & repair of leaks
- Screen hundreds of components an hour
- Screen inaccessible areas simply by viewing them

**Infrared Leak Detection**

- The following companies have helped Natural Gas STAR partners reduce methane emissions with optical leak imaging
  - FLIR Systems
  - ITT Industries – ANGEL Service
  - Leak Surveys Inc.

- The following companies have helped Natural Gas STAR partners reduce methane emissions with remote leak detection
  - Heath Consultants
FLIR Systems

GasFindIR
- Scan thousands of components per SHIFT
- Detect small leaks from several feet away
- Detect big leaks from hundreds of feet away
- Aerial surveillance of flowlines


ITT Industries – ANGEL Service

Airborne Natural Gas Emission Lidar (ANGEL) Service
- ANGEL system can detect, image, and map emissions of natural gas
- Samples more than 500 million cubic feet of atmosphere per minute
- Can survey more than 1,000 miles per day
- One plane can cover 25% of U.S. transmission pipelines per year

Leak Surveys Inc.

- HAWK System
  - LSI will provide pinpointed, real-time visualization of gas leaks recorded in standard digital video formats
  - Gas imaging is normally performed from up to 50 feet on the ground, 2 miles from the air
  - The time required to carry out the inspection is greatly reduced, with more complete leak detection

Heath Consultants

- Remote Methane Leak Detector (RMLD)
  - Detect leaks up to 100 feet away
  - Remote detection allows the user to safely survey areas that may be difficult to reach or access
  - Potential for productivity gains, reduced operations and maintenance costs, and a safer survey
Infrared Gas Imaging

- Video recording of fugitive leak found by infrared camera


Is Recovery Profitable?

<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>

*Based 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?