Directed Inspection and Maintenance (DI&M) at Gas Processing Plants

Lessons Learned from Natural Gas STAR Partners

Processors Technology Transfer Workshop

Pioneer Natural Resources, Inc., Gas Processors Association and EPA’s Natural Gas STAR Program

September 23, 2004
DI&M at Gas Processing Plants: Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions
Methane Losses

- Estimated 585 processing plants nationally
- Estimated 5,000 compressors in processing sector
- National fugitive and compressor seal methane emissions from processing plants is estimated to be 25 billion cubic feet per year (Bcf/yr)
- Estimated 43 million cubic feet (MMcf) per plant-yr methane emissions
  - **Worth $130,000/plant-yr**
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

- Gas plant fugitive methane emissions depend on operating practices, equipment age and maintenance
What are the Sources of Emissions?

- Compressor
- Compressor Seal
- Drain Valve
- Energy Exchange Pump
- FTS
- Dehydrator
- Contactor
- Reboiler
- Pressure Relief Valve
- Pneumatic Controller
Distribution of Losses by Source Category

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

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

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

Source: Clearstone Engineering, 2002
How Much Methane is Emitted?

## Methane Emissions from Leaking Components at Gas Processing Plants

<table>
<thead>
<tr>
<th>Component Type</th>
<th>% of Total Methane Emissions</th>
<th>% Leakers</th>
<th>Estimated Average Methane Emissions per Leaking Component (Mcf/Yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves (Block &amp; Control)</td>
<td>26.0 %</td>
<td>7.4 %</td>
<td>66</td>
</tr>
<tr>
<td>Connectors</td>
<td>24.4 %</td>
<td>1.2 %</td>
<td>80</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>23.4 %</td>
<td>81.1 %</td>
<td>372</td>
</tr>
<tr>
<td>Open-ended Lines</td>
<td>11.1 %</td>
<td>10.0 %</td>
<td>186</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>3.5 %</td>
<td>2.9 %</td>
<td>844</td>
</tr>
</tbody>
</table>

DI&M - Partner Experience

- Four gas processing plants were selected for joint EPA/GTI study of DI&M using high volume sampler.

- Initial estimates have been shown to be 40% lower than actual component count during baseline study.

- Final component count:
  - Plant 1 - 16,050 components
  - Plant 2 - 14,424 components
  - Plant 3 - 56,463 components
  - Plant 4 - 14,168 components
How Much Methane is Emitted?

### Summary of Natural Gas Losses from the Top Ten Leakers

<table>
<thead>
<tr>
<th>Plant No.</th>
<th>Gas Losses From Top 10 Leakers (Mcf/d)</th>
<th>Gas Losses From All Equipment Leakers (Mcf/d)</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 leak detection and repair (VOC LDAR) program
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 - find the 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
# How Do You Implement DI&M?

## Summary of Screening and Measurement Techniques

<table>
<thead>
<tr>
<th>Instrument/ Technique</th>
<th>Effectiveness</th>
<th>Approximate Capital Cost¹</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>
</tbody>
</table>

Source: EPA’s Lessons Learned Study
Estimating Comprehensive Survey Cost

- Cost of complete screening using High Volume Sampler
  - Ranges $15,000 - $20,000 per medium size plant
  - Rule of Thumb: $1 per component for an average plant

- 25 - 40% cost reduction for follow-up survey
## Cost-Effective Examples

<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>12,641</td>
<td>200</td>
<td>0.2</td>
</tr>
<tr>
<td>Union: Fuel Gas Line</td>
<td>12,155</td>
<td>100</td>
<td>0.1</td>
</tr>
<tr>
<td>Threaded Connection</td>
<td>10,446</td>
<td>10</td>
<td>0.0</td>
</tr>
<tr>
<td>Distance Piece: Rod Packing</td>
<td>7,649</td>
<td>2,000</td>
<td>3.1</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>6,959</td>
<td>60</td>
<td>0.1</td>
</tr>
<tr>
<td>Compressor Seals</td>
<td>5,783</td>
<td>2,000</td>
<td>4.2</td>
</tr>
<tr>
<td>Gate Valve</td>
<td>4,729</td>
<td>60</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Source: Hydrocarbon Processing, May 2002

1 Based on $3/Mcf gas price
Total Loss Reductions that are Cost-Effective to Find and Fix for Gas Plants

<table>
<thead>
<tr>
<th></th>
<th>&lt; 6 Months</th>
<th>&lt;1 Year</th>
<th>&lt;2 Years</th>
<th>&lt;4 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss Reduction</td>
<td>78.0%</td>
<td>92.3%</td>
<td>93.1%</td>
<td>94.5%</td>
</tr>
</tbody>
</table>

Reduction Emissions, Increasing Efficiency, Maximizing Profits
### Economic Analysis of DI&M of OELs

#### Economics Analysis of DI&M of Open-Ended Lines at Large and Small Gas Plants

<table>
<thead>
<tr>
<th></th>
<th>Large</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Plants OELs (Man-day/yr)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inspection of Booster OELs (Man-day/yr)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Inspection Prep and Record (Man-day/yr)</td>
<td>NA</td>
<td>3</td>
</tr>
<tr>
<td>Repairs &amp; Maintenance (Man-days)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Labor Cost ($/day)</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Total Labor Cost ($/yr)</td>
<td>2,000</td>
<td>4,500</td>
</tr>
<tr>
<td>Methane Savings (Mcf/yr)</td>
<td>3,319</td>
<td>4,526</td>
</tr>
<tr>
<td>Gas Savings (Mcf/yr)²</td>
<td>3,688</td>
<td>5,029</td>
</tr>
<tr>
<td>Gas Saving Value $/yr)</td>
<td>11,064</td>
<td>15,087</td>
</tr>
<tr>
<td>Payback (yr)</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

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1. Assumes two inspections per year
2. Gas values based on $3/Mcf
Case Study: Dynegy

- Surveyed components in two processing plants: 30,208
- Identified leaking components: 1,156 ~ 3.8%
- Repaired components: 80-90% of the identified leaking components
- Annual methane emissions reductions: 100,000 thousand cubic feet per year (Mcf/yr)
- Annual savings: $300,000 / year (at $3/Mcf)
DI&M Partner Experience: BP

- One large gas plant to date - 40,000 components

- Results
  - 938 equipment leaks identified – 37 MMcf/yr
    - 50% of volume from top 31 leaks
    - 75% of the volume from top 83 leaks
  - 48 compressor seals checked – 20 MMcf/yr
    - 16 leaks
    - 50% of volume from top 2 seals
    - 80% of volume from top 6 seals
  - One “water” tank issue found – 66 MMcf/yr

- Ten-year net present value is $2.4 MM; Payout is 2 months
Success #1: A leaking cylinder head was tightened, which reduced methane emissions from almost 64,000 Mcf/yr to 3,300 Mcf/yr. The repair required 9 man-hours of labor, and the annualized gas savings were approximately 60,700 Mscf/yr. The estimated value of the gas saved was $182,100/yr.

Success #2: A one-inch pressure relief valve emitted almost 36,774 Mcf/yr. Five man-hours of labor and $125 of materials eliminated the leak. The annualized value of the gas saved was more than $110,300.

Gas values based on $3/Mcf
Success #3: A blowdown valve leaked almost 14,500 Mcf/yr. Rather than replace the expensive valve, the Partner spent just $720 on labor and materials to reduce the emissions to approximately 100 Mscf/yr. The gas saved was approximately 14,400 Mcf/yr, worth $43,200.

Success #4: A tube fitting leaked 4,121 Mcf/yr. A very quick repair requiring only five minutes reduced the leak rate to 10 Mcf/yr. The annualized value of the gas saved was approximately $12,300.
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 Gas Imaging Technology

- Shoulder- and/or tripod-mounted
  - Hand-held prototype
- Aerial surveillance applications
- Require battery and/or power cord
- Most very large leaks (> 3cf/hr) clearly seen
Infrared Gas Imaging

- Video recording of fugitive leak found by infrared camera
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 about to change dramatically with new technology.

Team available to survey limited number of gas plants at discount cost as part of EPA grant. Call Roger Fernadez at 202-343-9086 for details.
Discussion Questions

- To what extent are you implementing this BMP?
- How can this BMP be improved upon or altered for use in your operation(s)?
- What are the barriers (technological, economic, lack of information, regulatory, etc.) that are preventing you from implementing this technology?