Gas STAR Technologies and Practices for DI&M and Compressor Seals

(Opportunities for Cost Effective Methane Sensors)

EPA’s Natural Gas STAR Program,
El Paso Corporation, and
Southern Gas Association
October 27, 2003
Agenda

- **Equipment leaks**
  - What is the problem?
  - Where are the leaks?
  - What Gas STAR Partners are doing.
  - A low-cost sensor option.

- **Compressor seals**
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Equipment leaks
What is the Problem?

- STAR partners find that valves, connectors, compressors and open-ended lines (OEL) are major leak sources
  - 50.7 Bcf/yr of methane are emitted by compressors and facility components
  - 1% of the leakers contribute 90% of the emissions
- Fugitive emissions depend on operating practices, equipment age and maintenance
Distribution of Natural Gas Losses by Source Category

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

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

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

Source: Clearstone Engineering, 2002

Reducing Emissions, Increasing Efficiency, Maximizing Profits
Where are the leaks?

- Valves account for 30%
  - Block valves = 26%
  - Control valves = 4%
- Stem seal leaks are the primary source
  - Balance between packing pressure and valve movement force
  - Packing wears, requiring either more pressure or replacement
Where are the leaks?

- Open ended lines (OEL) account for 11%
  - Block valves
  - Blowdown vents, motor starters, vent and drain connections

- Through-valve leakage is the primary source
  - Often from vent stacks
  - Valve seat wears or fouls, requiring either more pressure, cleaning or replacement
Where are the leaks?

- Pressure Relief Valves (PRV) account for 3.5%
  - Fewer of them, so higher individual leakage
  - Protect equipment from over-pressure
- Through-valve leakage is the primary source
  - Often from vent stacks
  - Valve seat wears or fouls, requiring either cleaning or replacement
What Gas STAR Partners are doing?

- Implementing a Directed Inspection and Maintenance Program (DI&M)
  - 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

Acoustic Leak Detection

Leak Measurement Using a High Volume Sampler
## Current DI&M 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 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
Cost-Effective Repair Examples

<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>12,641</td>
<td>200</td>
<td>0.2</td>
</tr>
<tr>
<td>Open-Ended Line</td>
<td>6,959</td>
<td>60</td>
<td>0.1</td>
</tr>
<tr>
<td>Pressure Relief Valve</td>
<td>982</td>
<td>293</td>
<td>3.5</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
Opportunities for Inexpensive Leak Sensors

- **Application:** Valves, Open-Ended Lines (OELs), Pressure Relief Valves (PRVs)

- **Objective:** Automated detection of LARGE leaks that are cost-effective to repair

- **Potential application:**
  
  - Business as usual site visit
  - Equipment alerts operator to cost-effective leak
  - Operator directs repairs on the spot
DI&M – Transmission Partner Experience

**Partner A:** 15 Stations surveyed annually
- Survey and repairs averaged $350/station
- Methane savings averaged 11,067 Mcf/station

  - Total Gas Savings $498,030
  - Total DI&M Cost $(5,250)
  - SAVINGS $492,780

**Partner B:** 2 Stations surveyed quarterly
- Survey costs $200/station
- 24 leaks detected & repaired; 23 repaired at average $50 each

  - Total Gas Savings $51,240
  - Total DI&M Cost $(2,750)
  - SAVINGS $48,490
Compressor seals
What is the problem?

- Compressor seals account for 23.4% of emissions
  - 11.9 Bcf/yr of methane are emitted by compressors
  - Over 8,500 compressors in gas transmission sector
Where are the leaks?

- Reciprocating compressor rod packing
  - Fourth largest gas industry emissions at 16 Bcf/yr
- Leakage typically occurs from:
  - Nose gasket
  - Between cups
  - Ring movement
  - Down shaft
- All packings leak
  - ~60 scfh new
  - >900 scfh worn
Where are the leaks?

- **Centrifugal compressor wet seals**
  - 90% of new compressors for transmission are centrifugal

- **Leakage typically occurs from**:
  - Labyrinth seal into seal oil
  - Seal oil degassing vent
  - Very little leakage from seal face

- **Seal oil vents emit**
  - 40-200 scfm

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*Reducing Emissions, Increasing Efficiency, Maximizing Profits*
Where are the leaks?

- **Centrifugal compressor dry seals**
  - Most new compressors are supplied with dry seals

- **Leakage typically occurs from:**
  - Labyrinth seal into static barrier
  - Seal vent after tandem seal
  - Little leakage from seal face

- **Seal vents emit**
  - 0.5-3 scfm
What Gas STAR Partners are doing.

- Leakage is reduced through routine monitoring and seal maintenance
  - Conventional rod packing rings require replacement every 3 to 5 years
- An economic leak rate is determined based on costs and gas savings
- Replace rings when it is economical
  - Saves gas and money
  - Extends the life of the piston rod
  - Reduces methane emissions
Best Practice Compressor Emissions Control
Compressor Rod Packing Systems

- Partners develop an “economic replacement threshold” that defines the point when it is cost-effective to replace rings and rods

\[
\text{Economic Replacement Threshold (scfh)} = \frac{(CR \times DF)}{[(H \times GP) / 1,000]}
\]

where:

- \( CR \) = cost of replacement ($)
- \( DF \) = company discount factor (%)
- \( H \) = hours of compressor operation
- \( GP \) = gas price ($/Mcf)
Economic Analysis
Compressor Rod Packing System

### Economic Replacement Threshold for Packing Rings

<table>
<thead>
<tr>
<th>LRE (scfh)</th>
<th>Payback Period&lt;sup&gt;1&lt;/sup&gt; (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>1</sup> Assumes packing ring replacement costs of $1,200, $3.00/Mcf gas and 8,000 hr/yr

### Economic Replacement Threshold for Rod and Rings

<table>
<thead>
<tr>
<th>LRE (scfh)</th>
<th>Payback Period&lt;sup&gt;1&lt;/sup&gt; (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>564</td>
<td>1</td>
</tr>
<tr>
<td>295</td>
<td>2</td>
</tr>
<tr>
<td>206</td>
<td>3</td>
</tr>
<tr>
<td>162</td>
<td>4</td>
</tr>
<tr>
<td>135</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>1</sup> Assumes packing ring replacement costs of $1,200, rod replacement cost of $7,000, $3.00/Mcf gas and 8,000 hr/yr
Opportunities for Inexpensive Leak Sensors

- Application: Compressor seal and seal oil vents
- Objective: Automated detection of LARGE leaks that are cost-effective to repair
- Potential application:
  - Business as usual site visit
  - Equipment alerts operator to cost-effective leak
  - Operator schedules cost-effective repairs
Company Experience

- One partner conducted semi-annual inspections of compressor rod packing
  - Replaced packing cases at eight stations costing $1,050 per case, installed
  - Saved 55 MMcf/yr valued at $165,000
Discussion Questions

- How accurate would sensors need to be in quantifying methane emissions?
- Would methane emissions sensor outputs need to be transmitted to a SCADA center?
- To what degree are candidate sites for low cost fugitive sensors non-electrified?
- What are other applications for inexpensive methane emissions sensors?