Lessons Learned from the Natural Gas STAR Program

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epa.gov/gasstar

**Best Management Practices: Agenda**

- Plunger Lifts and Smart Automation Well Venting
  - Methane Losses
  - Methane Savings
  - Is Recovery Profitable?
- Pneumatics
  - Methane Losses
  - Methane Savings
  - Is Recovery Profitable?
- Directed Inspection and Maintenance Overview
- Discussion
Wells: Methane Losses

- There are over 414,000 natural gas and condensate wells (on and offshore) in the U.S.\(^1\)
- Accumulation of liquid hydrocarbons or water in the well bores reduces, and can halt, production
- Common “blow down” practices to temporarily restore production can vent 80 to 1600 Mcf/year\(^2\) to the atmosphere per well
- Estimated 9.05 Bcf/year methane emissions from U.S. onshore well venting\(^1\)

2 - Mobil Big Piney Case Study 1997

What is the Problem?

- Conventional plunger lift systems use gas pressure buildups to repeatedly lift columns of fluid out of well
- Fixed timer cycles may not match reservoir performance
  - Cycle too frequently (high plunger velocity)
  - Plunger not fully loaded
  - Cycle too late (low plunger velocity)
    - Shut-in pressure can’t lift fluid to top
    - May have to vent to atmosphere to lift plunger

Source: Weatherford
Conventional Plunger Lift Operations

- Manual, on-site adjustments tune plunger cycle time to well’s parameters
  - Not performed regularly
  - Do not account for gathering line pressure fluctuations, declining well performance, plunger wear
- Results in manual venting to atmosphere when plunger lift is overloaded

Methane Recovery: How Smart Automation Reduces Methane Emissions

- Smart automation continuously varies plunger cycles to match key reservoir performance indicators
  - Well flow rate
    - Measuring pressure
  - Successful plunger cycle
    - Measuring plunger travel time
- Plunger lift automation allows producer to vent well to atmosphere less frequently
Automated Controllers

- Low-voltage; solar recharged battery power
- Monitor well parameters
- Adjust plunger cycling

Remote well management
- Continuous data logging
- Remote data transmission
- Receive remote instructions
- Monitor other equipment

Source: Weatherford

Plunger Lift Cycle without Smart Automation

Production Control Services
Spiro Formation Well 9N-27E

Well production without Plunger Lift
Potential Continuous Production with Plunger Lifts
Potential Incremental Production with Plunger Lift

Well Blowdowns
Methane Savings with Smart Automation

- Methane emissions savings a secondary benefit
  - Optimized plunger cycling to remove liquids increases well production by 10 to 20%\(^1\)
  - Additional 10%\(^1\) production increase from avoided venting
- 500 Mcf/year methane emissions savings for average U.S. well

\(^1\) - Reported by Weatherford

Other Benefits

- Reduced manpower cost per well
- Continuously optimized production conditions
- Remotely identify potential unsafe operating conditions
- Monitor and log other well site equipment
  - Glycol dehydrator
  - Compressor
  - Stock Tank
  - Vapor Recovery Unit
Is Recovery Profitable?

- Smart automation controller installed cost: ~$11,000
- Conventional plunger lift timer: ~$5,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production

Savings =

(Mcf/year) x (10% increased production) x (gas price)
+ (Mcf/year) x (1% emissions savings) x (gas price)
+ (personnel hours/year) x (0.5) x (labor rate)

$ savings per year

Economic Analysis

- Non-discounted savings for average U.S. Well =

(50,000 Mcf/year) x (10% increased production) x ($7/Mcf)
+ (50,000 Mcf/year) x (1% emissions savings) x ($7/Mcf)
+ (500 personnel hours/year) x (0.5) x ($30/hr)
- ($11,000) cost

$35,000 savings in first year

3 month simple payback
Industry Experience

- BP reported installing plunger lifts with automated control systems on ~2,200 wells
  - 900 Mcf reported annual savings per well
  - $12 million costs including equipment and labor
  - $6 million total annual savings
- Another company shut in mountaintop wells inaccessible during winter
  - Installed automated controls allowed continuous production throughout the year


Pneumatic Devices: What is the Problem?

- Pneumatic devices are major source of methane emissions from the natural gas industry
- Pneumatic devices used throughout the natural gas industry
  - Over 400,000 in production sector
  - About 13,000 in processing sector
  - Over 84,000 in transmission sector

Location of Pneumatic Devices at Production Sites

- **SOV** = Shut-off Valve (Unit Isolation)
- **LC** = Level Control (Separator, Contactor, Flash Tank Separator, TEG Regenerator)
- **TC** = Temperature Control (Regenerator Fuel Gas)
- **FC** = Flow Control (TEG Circulation, Compressor Bypass)
- **PC** = Pressure Control (FTS Pressure, Compressor Suction/Discharge)

Methane Emissions

- As part of normal operations, pneumatic devices release natural gas to atmosphere
- High-bleed devices bleed in excess of 6 cf/hour
  - Equates to >50 Mcf/year
  - Typical high-bleed pneumatic devices bleed an average of 140 Mcf/year
- Actual bleed rate is largely dependent on device’s design
How Can Methane Emissions be Recovered?

- **Option 1:** Replace high-bleed devices with low-bleed devices

- **Option 2:** Retrofit controller with bleed reduction kits
  - Field experience shows that up to 80% of all high-bleed devices can be replaced or retrofitted with low-bleed equipment

- **Option 3:** Maintenance aimed at reducing losses
Option 1: Replace High-Bleed Devices

- Most applicable to:
  - Controllers: liquid-level and pressure
  - Positioners and transducers
- Suggested action: evaluate replacements
  - Replace at end of device’s economic life
  - Early replacement

Source: www.norriseal.com

Source: www.emersonprocess.com

Option 1: Cost to Replace High-Bleed Devices

- Costs vary with size
  - Typical costs range from $700 to $3,000 per device
  - Incremental costs of low-bleed devices are modest ($150 to $250)
  - Gas savings often pay for replacement costs in short periods of time (2 to 8 months)
Option 2: Retrofit with Bleed Reduction Kits

- Applicable to most high-bleed controllers
- Suggested action: evaluate cost-effectiveness as alternative to early replacement
- Retrofit kit costs ~ $500
- Payback time ~ 9 months

Option 3: Maintenance to Reduce Losses

- Applies to all pneumatic devices
- Suggested action: add to routine maintenance procedures
  - Field survey of controllers
  - Where process allows, tune controllers to minimize bleed
Option 3: Maintenance to Reduce Losses (cont’d)

- Suggested action (cont’d)
  - Re-evaluate the need for pneumatic positioners
  - Repair/replace airset regulators
  - Reduce regulated gas supply pressure to minimum
  - Routine maintenance should include repairing/replacing leaking components

- Costs are low

Source: www.bpa950.com

Five Steps for Reducing Methane Emissions from Pneumatic Devices

1. Locate and INVENTORY high-bleed devices
2. ESTABLISH the technical feasibility and costs of alternatives
3. ESTIMATE the savings
4. EVALUATE economics of alternatives
5. DEVELOP an implementation plan
Suggested Analysis for Replacement

- Replacing high-bleed controllers at end of their economic life
  - End of economic life when major overhaul required
  - Determine incremental cost of low-bleed device over high-bleed equivalent
  - Determine gas saved with low-bleed device using manufacturer specifications
  - Compare savings and cost

- Early replacement of high-bleed controllers
  - Compare gas savings of low-bleed device with full cost of replacement

Economics of Replacement

<table>
<thead>
<tr>
<th>Implementation¹</th>
<th>Replace at End of Life</th>
<th>Early Replacements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Level Control</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>150 – 250²</td>
<td>380</td>
</tr>
<tr>
<td>Annual Gas</td>
<td>50 – 200</td>
<td>166</td>
</tr>
<tr>
<td>Savings (Mcf)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Value</td>
<td>350 – 1400</td>
<td>1162</td>
</tr>
<tr>
<td>of Saved Gas ($)³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR (%)</td>
<td>138 – 933</td>
<td>306</td>
</tr>
<tr>
<td>Payback (months)</td>
<td>2 – 9</td>
<td>4</td>
</tr>
</tbody>
</table>

1 - All data based on partners' experiences. See Lessons Learned for more information
2 - Range of incremental costs of low-bleed over high bleed equipment
3 - Gas price is assumed to be $7/Mcf
Suggested Analysis for Retrofit

- Retrofit of low-bleed kit
  - Compare savings of low-bleed device with cost of conversion kit
  - Retrofitting reduces emissions by average of 90%

<table>
<thead>
<tr>
<th></th>
<th>Retrofit(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation Costs(^2)</td>
<td>$500</td>
</tr>
<tr>
<td>Bleed rate reduction (Mcf/device/year)</td>
<td>219</td>
</tr>
<tr>
<td>Value of gas saved ($/year)(^3)</td>
<td>1533</td>
</tr>
<tr>
<td>Payback (months)</td>
<td>4</td>
</tr>
<tr>
<td>IRR</td>
<td>306%</td>
</tr>
</tbody>
</table>

\(^1\) - On high-bleed controllers
\(^2\) - All data based on partners’ experiences. See Lessons Learned for more information.
\(^3\) - Gas price is assumed to be $7/Mcf.

Suggested Analysis for Maintenance

- For maintenance aimed at reducing gas losses
  - Measure gas loss before and after procedure
  - Compare savings with labor (and parts) required for activity

<table>
<thead>
<tr>
<th></th>
<th>Reduce Supply Pressure</th>
<th>Repair &amp; Retune</th>
<th>Change Settings</th>
<th>Remove Valve Positioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation Cost ($)(^1)</td>
<td>153</td>
<td>23</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gas Savings (Mcf/year)</td>
<td>175</td>
<td>44</td>
<td>88</td>
<td>158</td>
</tr>
<tr>
<td>Value of gas saved ($/year)(^2)</td>
<td>1225</td>
<td>308</td>
<td>616</td>
<td>1106</td>
</tr>
<tr>
<td>Payback (months)</td>
<td>1.5</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>IRR</td>
<td>801%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\) - All data based on partners’ experiences. See Lessons Learned for more information.
\(^2\) - Gas price is assumed to be $7/Mcf.
Lessons Learned

- Most high-bleed pneumatics can be replaced with lower bleed models
- Replacement options save the most gas and are often economic
- Retrofit kits are available and can be highly cost-effective
- Maintenance is low-cost and reduces gas loss

Case Study – Marathon

- Surveyed 158 pneumatic devices at 50 production sites
- Half of the controllers were low-bleed
- High-bleed devices included
  - 35 of 67 level controllers
  - 5 of 76 pressure controllers
  - 1 of 15 temperature controllers
- Measured gas losses total 5.1 MMcf/year
- Level controllers account for 86% of losses
  - Losses averaged 7.6 cf/hour/device
  - Losses ranged up to 48 cf/hour/device (420 Mcf/year)
- Concluded that excessive losses can be heard or felt
Recommendations

- Evaluate all pneumatics to identify candidates for replacement and retrofit
- Choose lower bleed models at change-out where feasible
- Identify candidates for early replacement and retrofits by doing economic analysis
- Improve maintenance
- Develop an implementation plan

Directed Inspection and Maintenance

Source: Chevron
Source: Hy-bin Engineering
What is the problem?

- Methane 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, 70 Bcf of methane was emitted as fugitive by reciprocating compressor components alone.
  - Production and processing fugitive methane emissions depend on operating practices, equipment age and maintenance.

Sources of Methane Emissions
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

- DI&M is NOT the regulated volatile organic compound leak detection and repair (VOC LDAR) program

How Do You Implement DI&M?

1. CONDUCT baseline survey
2. SCREEN and MEASURE leaks
3. FIX on the spot leaks
4. ESTIMATE repair cost, fix to a payback criteria
5. DEVELOP a plan for future DI&M
6. RECORD savings/REPORT to Natural 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
  - Infrared leak detection

How Do You Implement DI&M?

- Evaluate the leaks detected - measure results
  - High volume sampler
  - Toxic vapor analyzer (correlation factors)
  - Rotameters
  - Calibrated bagging

Source: Heath Consultants
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 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
$ - Smallest capital cost
*** - Most effective at screening/measurement
 $$$ - Largest capital cost

Estimating Comprehensive Survey Cost

- Cost of complete screening survey using high volume sampler
  - Ranges $15,000 to $20,000 per medium size plant
  - Rule of Thumb: $1 per component for an average plant environment (based on processing plants)
  - Cost per component for remote small 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)
DI&M by 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

Infrared Methane Leak Detection

- Video recording of fugitive leaks detected by various infrared devices
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>29,498</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

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 valves, engine-starters, and pressure relief valves represent <3% of components but >60% of methane emissions
- The business of leak detection has changed dramatically with new technology

Source: Chevron
Discussion Questions

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