Methane Emissions and Mitigation Opportunities for Natural Gas Actuated Pneumatic Devices

Dr. Leonard Nelms
Tetra Tech, Inc.

Denver, Colorado, February 11, 2014
Park City, Utah, February 13, 2014
Pollutants of Concern from Natural Gas Venting

• VOCs

• Methane

• VOC HAPs from Venting
  – Benzene
  – Toluene
  – Ethyl benzene
  – Xylenes
  – N-hexane
  – 2,2,4-trimethylpentane

• Hydrogen Sulfide and other sulfur compounds
O&G Sources Venting Methane

- Tanks storing production liquids
- Process and emergency vents
- Glycol dehydrator still column and flash tank
- Compressor seal leaks
- Gas Actuated pumps
- Pneumatic pressure and level controllers
- Liquid loading and unloading
- Amine acid gas treatment vessels
- Well liquid unloading
- Well testing venting
## Results of 2013 EDF/Industry Methane Emissions Study

<table>
<thead>
<tr>
<th>Category</th>
<th>2011 EPA GHG inventory net emissions,* Gg of CH₄/yr</th>
<th>Emission estimates from this report,† Gg of CH₄/yr</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources with emissions data useful for generating national emission estimates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion flowbacks from hydraulic fracturing</td>
<td>654*</td>
<td>18 (5-27)</td>
<td>Less than national estimate</td>
</tr>
<tr>
<td>Chemical Pumps</td>
<td>34*</td>
<td>68 (35-100)</td>
<td>Greater than national estimate</td>
</tr>
<tr>
<td>Pneumatic Controllers</td>
<td>355*</td>
<td>580 (518-826)</td>
<td>Greater than national estimate</td>
</tr>
<tr>
<td>Equipment Leaks</td>
<td>172-211*</td>
<td>291 (186-396)</td>
<td>Greater than national estimate</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1,215-1,254*</td>
<td>957±200 #</td>
<td>~250 Gg less than national estimate</td>
</tr>
<tr>
<td>Sources with limited measurement data, insufficient to make national estimates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well unloading (non-plunger lift)</td>
<td>149*</td>
<td>N/A</td>
<td>Limited data set with broad range of values (25-206 Gg)</td>
</tr>
<tr>
<td>Workovers without hydraulic fracturing</td>
<td>0.3*</td>
<td>N/A</td>
<td>Only one measurement in study</td>
</tr>
</tbody>
</table>

*Emissions from EPA national inventory are based on reported potential emissions less reductions
† Emission factors used for national estimate only represent activities and practices of participating companies.
# National emissions based on regionally weighted average

Source: Measurements of methane emissions at natural gas production sites in the United States, David Allen et al. PNAS October 29, 2013
## Results of 2013 EDF/Industry Methane Emissions Study (continued)

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<th>Emission estimates from this report,† Gg of CH₄/yr</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources not yet measured</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well unloading (plunger lift)</td>
<td>108</td>
<td>N/A</td>
<td>No measurements made</td>
</tr>
<tr>
<td>Workovers with hydraulic fracturing</td>
<td>143</td>
<td>N/A</td>
<td>No measurements made</td>
</tr>
<tr>
<td>Other sources not yet measured</td>
<td>891-930</td>
<td>N/A</td>
<td>No measurements made</td>
</tr>
<tr>
<td>Total methane emissions</td>
<td>2,545</td>
<td>2,300</td>
<td>~250 Gg less than national estimate</td>
</tr>
</tbody>
</table>

*Emissions from EPA national inventory are based on reported potential emissions less reductions
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# National emissions based on regionally weighted average
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Steps for Evaluating Pneumatic Controller Mitigation Options

• Identify existing sources (i.e., not constructed/modified after August 23, 2011 and subject to NSPS OOOO)
• Inventory high-bleed controller count
• Estimate CH\textsubscript{4} bleed rate by controller
• Evaluate the technical feasibility of replacing with a low- or no-bleed controller
• Is it technically and economically feasible to convert to instrument air?
• Evaluate tech feasibility of retrofitting the high-bleed controller with a bleed reduction kit
• Perform routine maintenance and repair leaking gaskets, fittings and seals
Other Operator Considerations

• The “Big Three”
  – Safety
  – Reliability
  – Cost

• The Rest of the Story
  – Size
  – Compatibility
  – Installation
  – Ease of maintenance
  – Lifetime

• Vendor preferences
OPTIONS
Low and No-bleed Pneumatic Valves
Convert High-bleed Pneumatic Units to Instrument Air

• **Benefits**
  – Natural gas is not used for actuation, eliminating methane emissions
  – Little modification is required beyond adding a compressed air source
  – Existing control systems can usually be retained

• **Challenges**
  – Well sites without access to the electric grid will require an air compressor driven by an internal combustion engine
  – Moisture removal from the instrument air is required
  – Residual moisture in the system may freeze in cold weather, blocking air flow
  – Capital, operating, and maintenance costs for air compression equipment must be considered
  – A back-up compressed air supply may be required for safety and operational reasons
Replace Pneumatic Controllers with Electric-actuated Valves

• **Benefits**
  – Electric actuators do not use natural gas to operate; i.e., no bleed
  – Electric activators are becoming more available

• **Challenges**
  – Electric actuators require electricity to operate
  – New or modified control systems will often be required
  – Some oil and gas wells are not located near the electric grid (however, some solar-powered units have been developed)
  – Not all electric actuators are considered fail-safe by some companies
  – Costs for electric-actuated units typically are significantly higher than those for pneumatic units
Examples of Electric-Actuated Valves
Future Developments

• Continued development of electric actuators will provide better, cheaper, and safer units

• Improved electric power sources (i.e., better solar panels, improved batteries, cost-effective fuel cells, etc.) will allow wider use of electric units at off-grid wells

• Better retrofit kits may provide opportunities for reduction in gas operating pressure, lowering bleed rates further

• Emerging technology (“artificial muscles,” linear electric drives, other as yet unidentified technologies) may provide additional affordable, reliable, and safe options in coming years
Emission Reductions Using O&M Plans

• General procedures to identify concerns
  – Listen for signs of leaking gas
  – Look for stains or drips from pneumatics
  – Note observations of hydrogen sulfide or hydrocarbon odors
  – Good housekeeping
  – Daily reports
    • oil & gas production rates
    • engine downtime/runtime
    • blowdown of natural gas systems
    • unplanned shut-ins
    • site inspection logs
  – Review emission inventory data on venting
  – Monitor upsets and start-up emissions
COSTS
What Are My Methane Mitigation Costs?

• Many options may be available

• Costs depend on:
  – How large is the facility?
  – New or retrofit technology?
  – Onshore or offshore location?
  – Is electric power from utilities available?
  – What is the composition of the natural gas?
  – What reduction must I achieve?
  – What is the value of the recovered gas locally?
  – What are design/engineering, shipping, installation, and local labor rates?
Replacement with Electric Actuators

• **Relative actuator cost compared to high-bleed controllers (1X)**
  - Small electric motor and gears (EMA) — 1.5X to 3X
  - Small electric motor and pump (EHA) — 2X to 6X
  - Large electric motor and gears (EMA) — 3X to 20X
  - Large electric motor and pump (EHA) — 3.5X to 30X

• **Cost for electric power source, if needed**
  - Connect to existing grid — $2,000 up, depending on location and distance
  - Installation of solar panels — Unknown; depends on design parameters
  - Installation of fuel cells — Unknown; depends on design parameters

• **Cost for upgrading/replacing control systems — Depends on design**
## Typical Air Compressor and Dryer Costs

### Air Compressor Costs

<table>
<thead>
<tr>
<th>Size</th>
<th>Air Capacity (cfm)</th>
<th>Type of Compressor</th>
<th>Horsepower Required</th>
<th>Equipment Cost ($)</th>
<th>Operating Cost ($/yr)</th>
<th>Service Life (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>30</td>
<td>Reciprocating</td>
<td>10</td>
<td>3,300</td>
<td>434</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>125</td>
<td>Screw</td>
<td>30</td>
<td>16,500</td>
<td>868</td>
<td>5-6</td>
</tr>
<tr>
<td>Large</td>
<td>350</td>
<td>Screw</td>
<td>75</td>
<td>29,000</td>
<td>868</td>
<td>5-6</td>
</tr>
</tbody>
</table>

### Air Dryer Costs

<table>
<thead>
<tr>
<th>Size</th>
<th>Air Capacity (cfm)</th>
<th>Dryer Type</th>
<th>-</th>
<th>Equipment Cost ($)</th>
<th>Operating Cost ($/yr)</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>30</td>
<td>Membrane</td>
<td>-</td>
<td>2,000</td>
<td>434</td>
<td>-</td>
</tr>
<tr>
<td>Medium</td>
<td>60</td>
<td>Membrane</td>
<td>-</td>
<td>5,900</td>
<td>868</td>
<td>-</td>
</tr>
<tr>
<td>Large</td>
<td>350</td>
<td>Alumina</td>
<td>-</td>
<td>13,100</td>
<td>868</td>
<td>-</td>
</tr>
</tbody>
</table>
## Economic Benefits of Reducing Pneumatic Device Emissions

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost ((^1)) ($)</th>
<th>Bleed Rate Reductions ((^2)) (Mcf/year/unit)</th>
<th>Annual Savings ((^3)) ($/yr)</th>
<th>Payback Period (Mo)</th>
<th>Internal Rate of Return ((^4)) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level controllers with low-bleed units</td>
<td>513</td>
<td>166</td>
<td>664</td>
<td>10</td>
<td>129</td>
</tr>
<tr>
<td>Pressure controllers with low-bleed units</td>
<td>1,809</td>
<td>228</td>
<td>912</td>
<td>24</td>
<td>50</td>
</tr>
<tr>
<td>Metal seal pressure controllers with soft-seal units</td>
<td>104</td>
<td>219</td>
<td>876</td>
<td>2</td>
<td>840</td>
</tr>
<tr>
<td>Retrofit Level Controllers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Mizer(^\text{®}) controls</td>
<td>675</td>
<td>219</td>
<td>876</td>
<td>10</td>
<td>130</td>
</tr>
<tr>
<td>Change from large to small orifices</td>
<td>41</td>
<td>184</td>
<td>736</td>
<td>1</td>
<td>1,800</td>
</tr>
<tr>
<td>Change from large to small nozzles</td>
<td>189</td>
<td>131</td>
<td>524</td>
<td>5</td>
<td>275</td>
</tr>
<tr>
<td>Retrofit Pressure Controllers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change from large to small orifices</td>
<td>41</td>
<td>184</td>
<td>736</td>
<td>1</td>
<td>1,800</td>
</tr>
</tbody>
</table>
### Economic Benefits of Reducing Pneumatic Device Emissions (continued)

<table>
<thead>
<tr>
<th>Action</th>
<th>Cost (1) ($)</th>
<th>Bleed Rate Reductions (2) (Mcf/year/unit)</th>
<th>Annual Savings (3) ($/yr)</th>
<th>Payback Period (Mo)</th>
<th>Internal Rate of Return (4) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce gas supply pressure</td>
<td>207</td>
<td>175</td>
<td>700</td>
<td>4</td>
<td>340</td>
</tr>
<tr>
<td>Repair Leaks and retune unit</td>
<td>31</td>
<td>44</td>
<td>176</td>
<td>2</td>
<td>570</td>
</tr>
<tr>
<td>Change gain setting on level controllers</td>
<td>0</td>
<td>88</td>
<td>352</td>
<td>Immediate</td>
<td>NM</td>
</tr>
<tr>
<td>Remove unnecessary positioners</td>
<td>0</td>
<td>158</td>
<td>632</td>
<td>Immediate</td>
<td>NM</td>
</tr>
<tr>
<td>Reduce gas supply pressure</td>
<td>207</td>
<td>175</td>
<td>700</td>
<td>4</td>
<td>340</td>
</tr>
</tbody>
</table>

(1) Represents average installed costs for one brand of pneumatic instrument (2006 basis)
(2) Bleed rate reduction = change in hourly bleed rate * 8,760 hours
(3) Savings based on $4.00/Mcf cost of natural gas
(4) Internal Rate of Return (IRR) calculated over five years

Source: Lessons Learned from Natural Gas STAR Partners “Options For Reducing Methane Emissions From Pneumatic Devices In The Natural Gas Industry” (October 2006)
Other Generally Helpful Hints

• Regular walks from wellhead through processing to sales points
• Improve operator (contract or company) knowledge base
• Develop and maintain operator experience
• Regular review of process/safety flow diagrams
• Identify all routine and non-routine venting sources/locations
• Identify all liquid level and pressure control devices
• Review data from [www.epa.gov/gasstar](http://www.epa.gov/gasstar) and related sources
ConocoPhillips Lower 48 Operations
Experience in Methane Emission Mitigation

May 11, 2010

Alena Jonas – COP Program Overview
John Gregoire – Conversion of High-Bleed Controllers
Gina Bertoglio – Success with Closed-Loop Completions in the San Juan Basin
Results ConocoPhillips Achieved for Converting High-Bleed Controllers

- Addressed conversion of high-bleed (>6 scf/hr) controllers
- Included three general applications
  - Liquid-level controllers
  - Suction and discharge pressure controllers
  - Sales-line pressure or flow controllers
- Replaced 5 liquid dump controllers emitting 13.2 scf/hr with new units emitting 2.52 scf/hr at 1 dump per minute
  - Projected reductions of 10.8 scf/hr and 94.6 Mcf/yr per unit
  - Total project potential reduction = 473 Mcf/yr
- Replaced 1 separator liquid controller bleeding 35 scf/hr with one with a bleed rate of 0.017 scf/hr, reducing bleed by 306 Mcf/year
- Replaced 6 liquid level controllers with low-bleed units, achieving a total potential reduction of 550 Mcf/yr
Gains from Converting Pneumatic Sense & Control to Digital Valve Control (DVC)

- Converted 3 suction pressure sense/control systems to low-bleed DVC units
  - Reduced bleed rate from 35 to 4.3 scf/hr per unit at 100% open
  - Total potential emission reduction of 269 Mcf/yr per system

- Changed 4 existing DVC controllers to low-bleed relays
  - Reduced bleed rate from 29.3 to 4.3 scf/hr per unit at 100% open
  - Total potential emission reduction of 219 Mcf/yr per controller

- Modified the well-site I/P pressure controllers by reducing operating pressure from 6-30 psi to 3-15 psi and the control valve spring from 30 to 20 psi
  - Reduced the potential bleed rate from 9.4 to 6.0 scf/hr at 100% open
  - Achieved a total potential reduction of 29Mcf/yr per controller
Conversion of High-Bleed Controllers – Considerations

• **Benefits**
  – Reduced methane loss
  – More manufacturers are providing low-bleed or no-bleed applications

• **Challenges**
  – On retro-fit applications – potential reduction is unique to the application and design of the system that it is operating.
  – Liquid dumps are dependent on liquid volume cycles and separator design.
  – Flow and/or Pressure Control Valves operate at different % of open. The operations depend on facility needs and line pressures.
  – One of the challenges during the project was gathering documented bleed rates on certain older models of controllers.
Contact Information

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