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

NaturalGas

EPA POLLUTION PREVENTER

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

Category	2011 EPA GHG inventory net emissions,* Gg of CH_4/yr	Emission estimates from this report,† Gg of CH_4/yr	Comments
Sources with emissions data useful for generating national emission estimates			
Completion flowbacks from hydraulic fracturing	654*	18 (5-27)	Less than national estimate
Chemical Pumps	34*	68(35-100)	Greater than national estimate
Pneumatic Controllers	355*	580 (518-826)	Greater than national estimate
Equipment Leaks	172-211*	291 (186-396	Greater than national estimate
Subtotal	1,215-1,254*	957±200 #	~250 Gg less than national estimate
Sources with limited measurement data, insufficient to make national estimates			
Well unloading (non-plunger lift)	149*	N/A	Limited data set with broad range of values (25-206 Gg)
Workovers without hydraulic fracturing	0.3*	N/A	Only one measurement in study

*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)

Category	2011 EPA GHG inventory net emissions,* Gg of CH_4/yr	Emission estimates from this report,† Gg of CH_4/yr	Comments
Sources not yet measured			
Well unloading (plunger lift)	108	N/A	No measurements made
Workovers with hydraulic fracturing	143	N/A	No measurements made
Other sources not yet measured	891-930	N/A	No measurements made
Total methane emissions	2,545	2,300	~250 Gg less than national estimate

*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

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_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

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

Air Dryer Costs

Size	Air Capacity (cfm)	Dryer Type	-	Equipment Cost ($)	Operating Cost ($/yr)	-
Small	30	Membrane	-	2,000	434	-
Medium	60	Membrane	-	5,900	868	-
Large	350	Alumina	-	13,100	868	-

Economic Benefits of Reducing Pneumatic Device Emissions

Action	Cost (1) ($)	Bleed Rate Reductions(2) (Mcf/year/unit	Annual Savings(3) ($/yr)	Payback Period (Mo)	Internal Rate of Return(4) (%)
Replace					
Level controllers with low-bleed units	513	166	664	10	129
Pressure controllers with low-bleed units	1,809	228	912	24	50
Metal seal pressure controllers with soft-seal units	104	219	876	2	840
Retrofit Level Controllers					
Install Mizer® controls	675	219	876	10	130
Change from large to small orifices	41	184	736	1	1,800
Change from large to small nozzles	189	131	524	5	275
Retrofit Pressure Controllers					
Change from large to small orifices	41	184	736	1	1,800

Economic Benefits of Reducing Pneumatic Device Emissions (continued)

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

(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 and related sources

Case Study Summary from 2010 EPA Gas STAR Workshop

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.

ConocoPhillips

Contact Information

Leonard H. Nelms, Ph.D.
Principal Air Program Manager
Tetra Tech, Inc.

2901 Wilcrest Drive, Suite 410
Houston, Texas 77042
Phone: (832) 251-5171
Fax: (832) 251-5170
e-mail: len.nelms@tetratech.com

Questions?