Best Management Practices and Key Issues for Small and Independent Producers

Lessons Learned from the
Natural Gas STAR Program

IOGCC

Marcellus Shale Basin Producers
Technology Transfer Workshop

Penn State, Pennsylvania
November 18, 2009

epa.gov/gasstar

Key Issues for Small Producers: Agenda

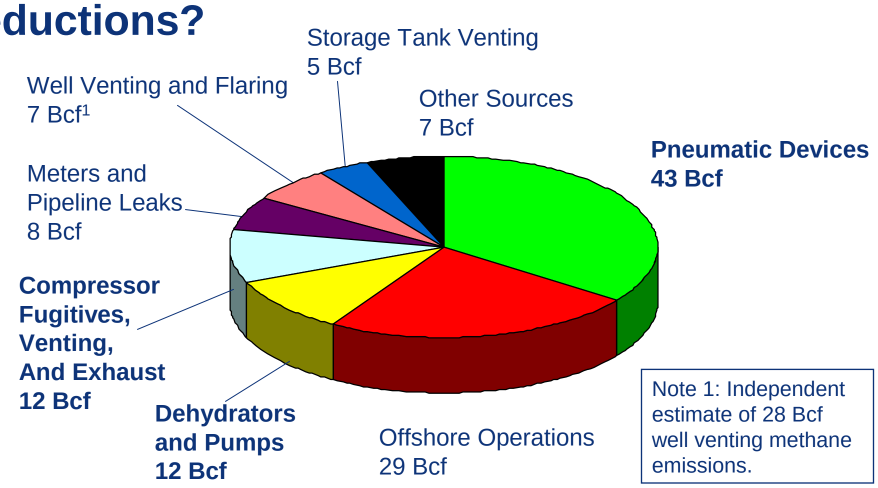
- Determining the appropriate emission reduction technologies
- Economic barriers to implementing technologies and practices
- Biggest opportunities for emissions reductions:
  - Pneumatic devices
  - Dehydrators
  - Compressor Rod Packing

Production in Pennsylvania

- In 2007, there were about 52,700 gas production wells producing 182 Bcf of dry gas
- That same year, EPA estimates 12 Bcf of gas may be vented or flared from unconventional well completions in Pennsylvania
- At $5.72[1] per Mcf, that equals about $70 million of lost revenue due to venting and flaring
- How much revenue are you losing?

1. EIA. 2007 Natural Gas Navigator. Retrieved 17 Jul 09 from <http://tonto.eia.doe.gov/dnav/ng/ng_prod_top.asp> 3

Where are your opportunities for emissions reductions?



Note 1: Independent estimate of 28 Bcf well venting methane emissions.

EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2007.* April, 2009. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html
Note: Natural Gas STAR reductions from gathering and boosting operations are reflected in the production sector. 4

Economic Barriers to Implementation

- Current and future gas prices
- Payback criteria and project feasibility

Additional Barriers to Implementation

- Lack of man-power
- Engaging management
- Lack of information

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Pneumatic Devices

Source: EnCana

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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 630,000 in production sector[1]
  - About 13,000 in processing sector[1]
  - About 83,000 in transmission sector[1]

1 - Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2007

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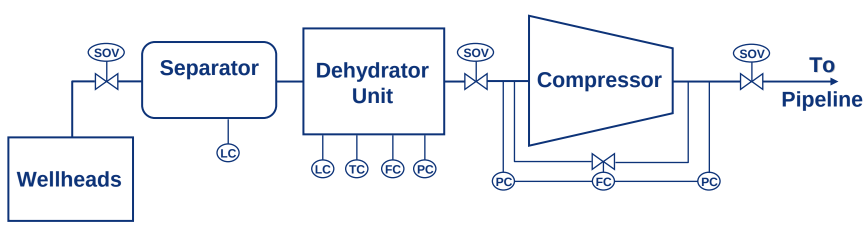
Location of Pneumatic Devices at Production Sites



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)

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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

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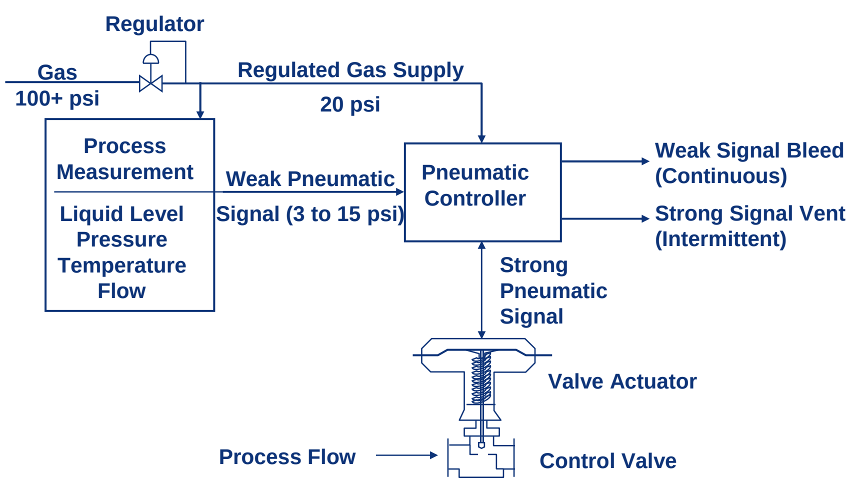
Pneumatic Device Schematic



psi = pounds per square inch

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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

Economics of Replacement & Retrofitting

Implementation[1]	Replace at End of Life	Retrofit		Early Replacements	
		Level Control[4]	Pressure Control	Level Control	Pressure Control
Cost ($)	150 – 250[2]	189	41	380	1,340
Annual Gas Savings (Mcf)	50 – 200	131	184	166	228
Annual Value of Saved Gas ($)[3]	350 – 1400	917	1,288	1162	1596
IRR (%)	138 – 933	>450	>3,100	306	117
Payback (months)	2 – 9	3	<1	4	10

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
4 – Large nozzle to small

Dehydrators

- Methane Losses
- Methane Recovery
- Is Methane Recovery Profitable?
- Partner Experience

Glycol Dehydrator Unit
Source: GasTech

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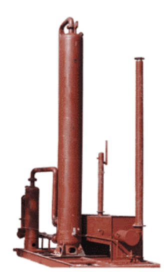
Glycol Dehydrators Emit?

- Produced gas is saturated with water, which must be removed for gas transmission
- Glycol dehydrators are the most common equipment to remove water from gas
  - 36,000 dehydration units in natural gas production, gathering, and boosting
  - Most use triethylene glycol (TEG)
- Glycol dehydrators create emissions
  - Methane, Volatile Organic Compounds (VOCs), Hazardous Air Pollutants (HAPs) from reboiler vent
  - Methane from pneumatic controllers



Source:
www.prideofthehill.com

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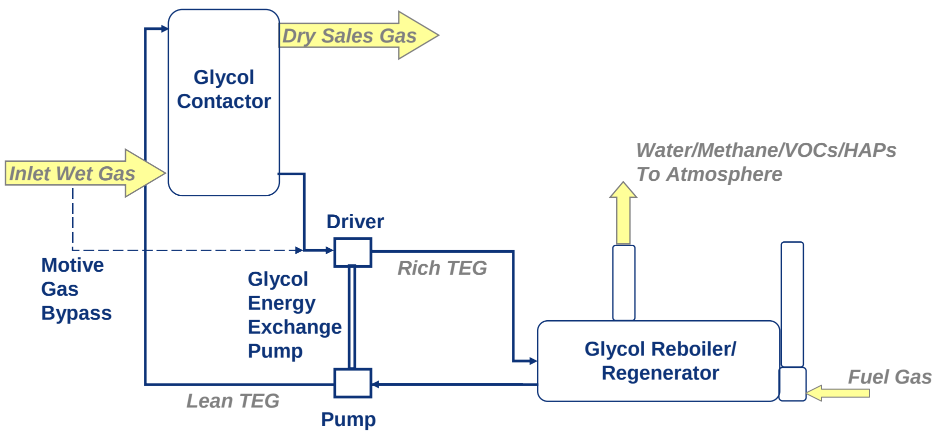
Basic Glycol Dehydrator System Process Diagram



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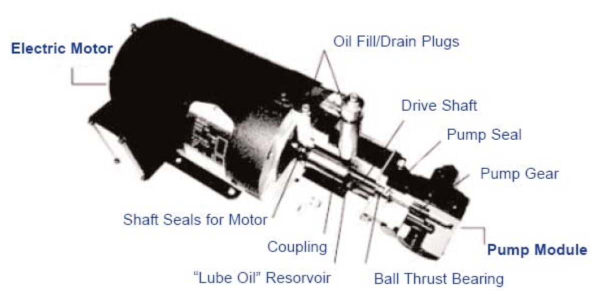
Methane Recovery

- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric Pumps



Source: Kimray Inc.

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Optimizing Glycol Circulation Rate

- Gas pressure and flow at wellhead dehydrators generally declines over time
  - Glycol circulation rates are often set at a maximum circulation rate
- Glycol overcirculation results in more methane emissions without significant reduction in gas moisture content
  - Partners found circulation rates two to three times higher than necessary
  - Methane emissions are directly proportional to circulation
- Lessons Learned study: optimize circulation rates

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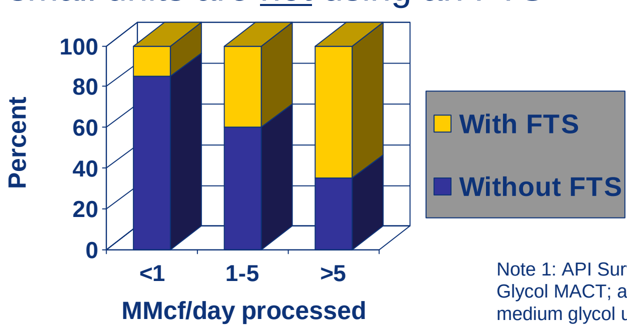
Installing Flash Tank Separator (FTS)

- Methane that flashes from rich glycol in an energy-exchange pump can be captured using an FTS
- Many small units are not using an FTS



MMcf = Million cubic feet

Source: API[1]

Note 1: API Survey prior to Glycol MACT; all large, half of medium glycol units now comply with MACT.

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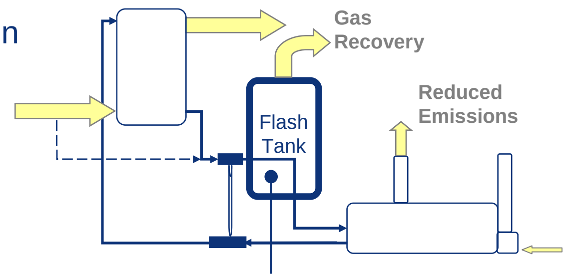
Methane Recovery

- Recovers about 90% of methane emissions
- Reduces VOCs by 10 to 90%
- Must have an outlet for low pressure gas
  - Fuel
  - Compressor suction
  - Vapor recovery unit



Low Capital Cost/Quick Payback

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Flash Tank Costs

- Lessons Learned study provides guidelines for scoping costs, savings and economics
- Capital and installation costs:
  - Capital costs range from $3,300 to $6,700 per flash tank
  - Installation costs range from $1,200 to $3,000 per flash tank
- Negligible Operational & Maintenance (O&M) costs

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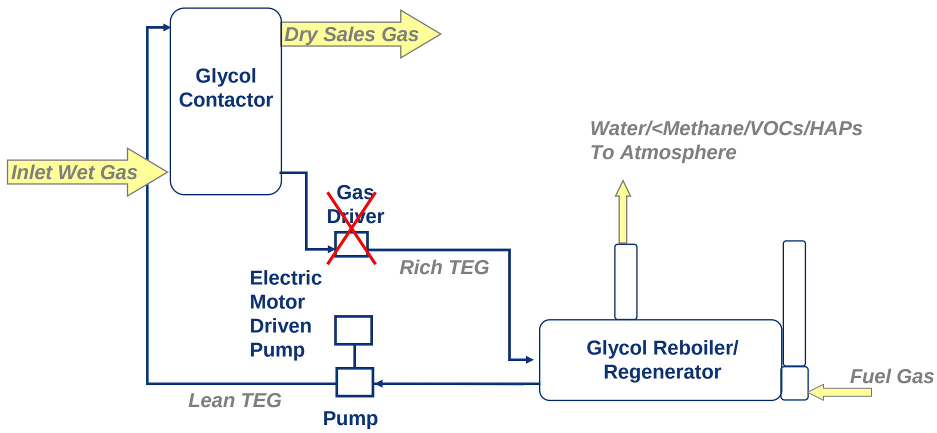
Electric Pump Eliminates Motive Gas



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Overall Benefits

- Financial return on investment through gas savings
- Increased operational efficiency
- Reduced O&M costs (fuel gas, glycol make-up)
- Reduced compliance costs (HAPs, BTEX)
- Similar footprint as gas assist pump

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Is Recovery Profitable?

Three Options for Minimizing Glycol Dehydrator Emissions

Option	**Capital Costs**	**Annual O&M Costs**	**Emissions Savings**	**Payback Period**[1]
Optimize Circulation Rate	Negligible	Negligible	394 to 39,420 Mcf/year	Immediate
Install Flash Tank	$6,500 to $18,800	Negligible	1,191 to 10,643 Mcf/year	4 to 11 months
Install Electric Pump	$1,400 to $13,000	$165 to $6,500	360 to 36,000 Mcf/year	< 1 month to several years

1 – Gas price of $7/Mcf

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Partner Experience (Shell)

- Installed flash tank separators on 106 dehydrators over 8 years
- Project cost = $15,000- $30,000 per FTS
- Annual Emissions reductions = 216 MMcf
- Annual Value Savings: $3.00/Mcf x 216 MMcf = $648,000
- 3 year pay-back period

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Reciprocating Compressors

- Methane Losses from Rod Packing
- Implementing Proper Seals
- Rod Packing Replacement Economics
- Low Emission Packing

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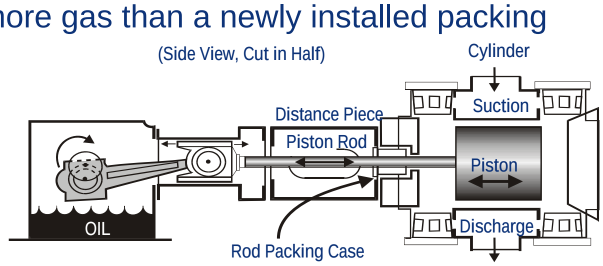
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour) in large compressors at processing plants or gathering and booster stations
  - Worn packing has been reported to leak up to 15 times more gas than a newly installed packing



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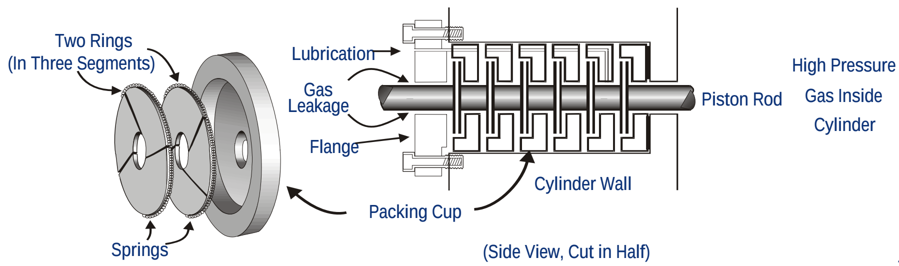
Reciprocating Compressor Rod Packing

- A series of flexible rings fit around the shaft to prevent leakage
- Leakage may still occur through nose gasket, between packing cups, around the rings, and between rings and shaft



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Methane Losses from Rod Packing

Transmission Compressors

Emission from Running Compressor	99	cf/hour-packing
Emission from Idle/Pressurized Compressor	145	cf/hour-packing
Leakage from Idle Compressor Packing Cup	79	cf/hour-packing
Leakage from Idle Compressor Distance Piece	34	cf/hour-packing

Leakage from Rod Packing on Running Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cf/hour)	70	63	150	24

Leakage from Rod Packing on Idle/Pressurized Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (cf/hour)	70	N/A	147	22

PRCI/ GRI/ EPA. *Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations*

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Steps to Determine Economic Replacement

- Measure rod packing leakage
  - When new packing installed – after worn-in
  - Periodically afterwards
- Determine cost of packing replacement
- Calculate economic leak reduction
- Replace packing when leak reduction expected will pay back cost

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Cost of Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $ 675 to $ 1,080
    (with cups and case) $ 2,025 to $ 3,375
  - Rods: $ 2,430 to $13,500
    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO

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Calculate Economic Leak Reduction

- Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements
  - This is a capital recovery economic calculation

Economic Replacement Threshold (cf/hour) = $\frac{CR * DF * 1{,}000}{(H * GP)}$

Where:

CR = **Cost of replacement ($)**

DF = **Discount factor at interest *i* =** $DF = \frac{i(1+i)^n}{(1+i)^n - 1}$

H = **Hours of compressor operation per year**

GP = **Gas price ($/thousand cubic feet)**

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Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement

CR = $1,620 for rings
H = 8,000 hours per year
GP = $7/Mcf

DF @ i = 10% and n = 1 year

$$DF = \frac{0.1(1+0.1)^1}{(1+0.1)^1 - 1} = \frac{0.1(1.1)}{1.1-1} = \frac{0.11}{0.1} = 1.1$$

DF @ i = 10% and n = 2 years

$$DF = \frac{0.1(1+0.1)^2}{(1+0.1)^2 - 1} = \frac{0.1(1.21)}{1.21-1} = \frac{0.121}{0.21} = 0.576$$

One year payback

***ER* = <u>$1,620 x 1.1 x 1,000</u>**
(8,000 x $7)
= 32 scf per hour

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Is Rod Packing Replacement Profitable?

- Replace packing when leak reduction expected will pay back cost
  - "leak reduction expected" is the difference between current leak rate and leak rate with new rings

Rings Only

Rings: $1,620
Rod: $0
Gas: $7/Mcf
Operating: 8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (months)
62	6
32	12
22	18
17	24

Rod and Rings

Rings: $1,620
Rod: $9,450
Gas: $7/Mcf
Operating: 8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (months)
425	6
217	12
148	18
114	24

Based on 10% interest rate
Mcf = thousand cubic feet

Industry Experience – Occidental

- Occidental upgraded compressor rod packing at its Elk Hills facility in southern California
- Savings 145 MMcf/yr
- Payback in under 3 years


Source: Occidental

Discussion Questions

- What industry experiences do you have applying these technologies and practices?
- What are your limitations on applying these technologies and practices?
- Actual costs and benefits