Producer Best Management Practices

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

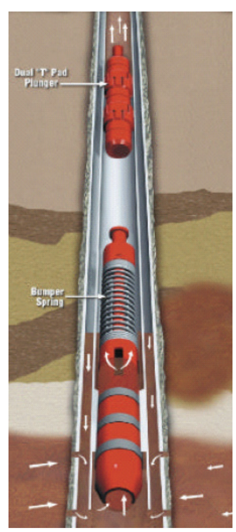
Wells: Methane Losses

- 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]

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

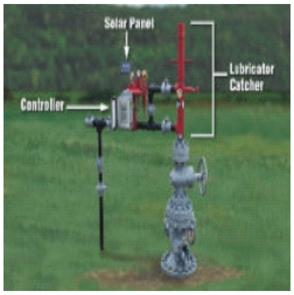
Conventional Plunger Lift Operations

- 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

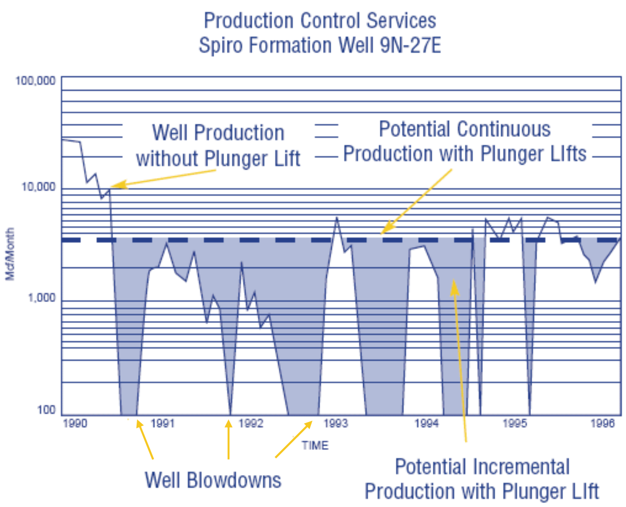


Source: Weatherford

- 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



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[1]

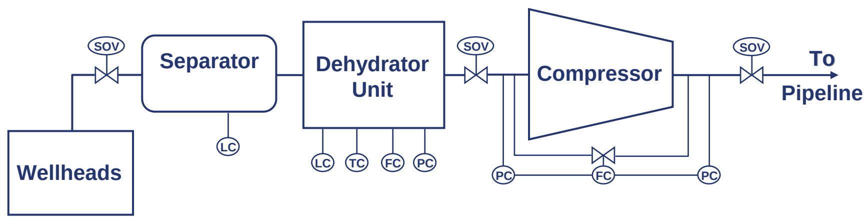
1 - Morrow, Stan and Stan Lusk, Ferguson Beauregard, Inc. Plunger-Lift: Automated Control Via Telemetry. 2000.

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[1]
  - About 13,000 in processing sector[1]
  - Over 84,000 in transmission sector[1]

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

Location of Pneumatic Devices at Production Sites

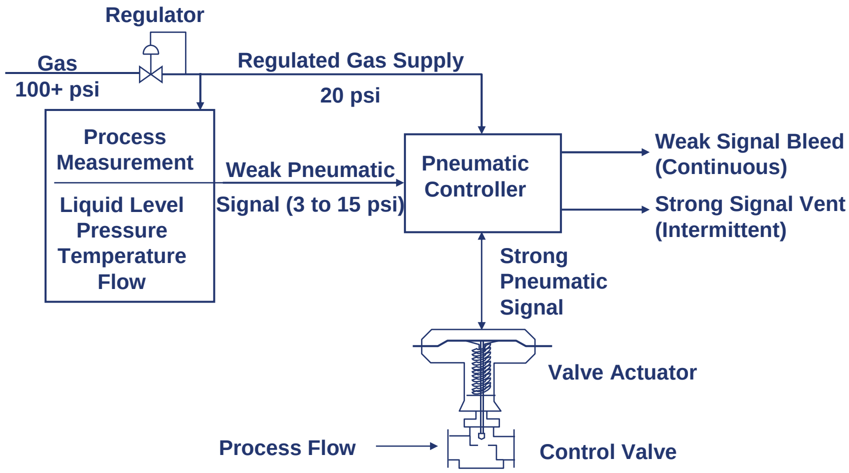


SOV = Shut-off Valve (Unit Isolation)
LC = Level Control (Separator, Contactor, Flash Tank Separator, TEG Regenerator)
TC = Temperature Control (Regenerator Fuel Gas)
FC = Flow Control (TEG Circulation, Compressor Bypass)
PC = Pressure Control (FTS Pressure, Compressor Suction/Discharge)

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

Pneumatic Device Schematic



psi = pounds per square inch

How Can Methane Emissions be Recovered?

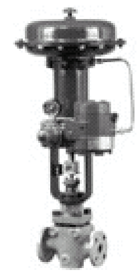
- **Option 1:** Replace high-bleed devices with low-bleed devices
- **Option 2:** Retrofit controller with bleed reduction kits
  - Field experience shows that up to 80% of all high-bleed devices can be replaced or retrofitted with low-bleed equipment
- **Option 3:** Maintenance aimed at reducing losses

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

Norriseal Pneumatic Liquid Level Controller

Source: www.norriseal.com



Fisher Electro-Pneumatic Transducer

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

Becker
Single-Acting
Valve Positioner

Source: www.bpe950.com

Five Steps for Reducing Methane Emissions from Pneumatic Devices

Locate and INVENTORY high-bleed devices

↓

ESTABLISH the technical feasibility and costs of alternatives

↓

ESTIMATE the savings

↓

EVALUATE economics of alternatives

↓

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

Implementation[1]	Replace at End of Life	Early Replacements	
		Level Control	Pressure Control
Cost ($)	150 – 250[2]	380	1,340
Annual Gas Savings (Mcf)	50 – 200	166	228
Annual Value of Saved Gas ($)[3]	350 – 1400	1162	1596
IRR (%)	138 – 933	306	117
Payback (months)	2 – 9	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

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%

	Retrofit[1]
Implementation Costs[2]	$500
Bleed rate reduction (Mcf/device/year)	219
Value of gas saved ($/year)[3]	1533
Payback (months)	4
IRR	306%

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

	Reduce Supply Pressure	**Repair & Retune**	**Change Settings**	**Remove Valve Positioners**
Implementation Cost ($)[1]	153	23	0	0
Gas Savings (Mcf/year)	175	44	88	158
Value of gas saved ($/year)[2]	1225	308	616	1106
Payback (months)	1.5	<1	<1	<1
IRR	801%	-	-	-

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

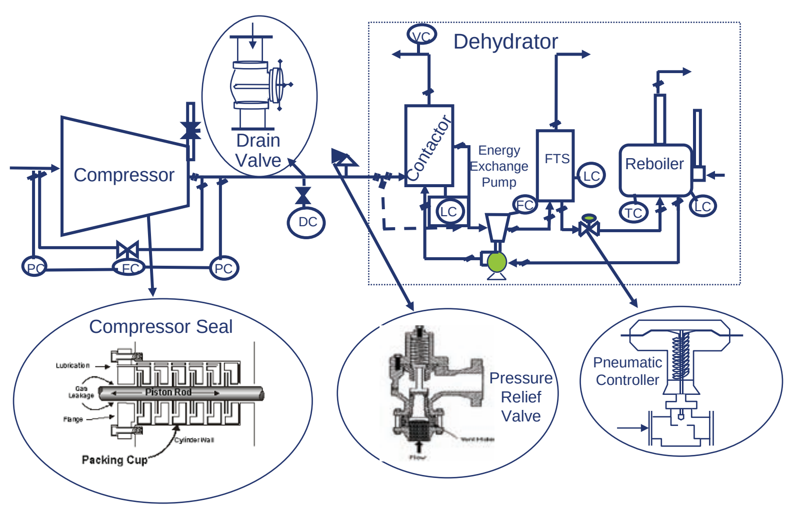
Source: Chevron

Source: Hy-bon 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

Source: Targa Resources

How Do You Implement DI&M?

CONDUCT baseline survey
↓
SCREEN and MEASURE leaks
↓
FIX on the spot leaks
↓
ESTIMATE repair cost, fix to a payback criteria
↓
DEVELOP a plan for future DI&M
↓
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

Toxic Vapor Analyzer

Acoustic 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

Leak Measurement Using High Volume Sampler

Source: Heath Consultants

How Do You Implement DI&M?

Summary of Screening and Measurement Techniques		
Instrument/ Technique	Effectiveness	Approximate Capital Cost
Soap Solution	★★	$
Electronic Gas Detector	★	$$
Acoustic Detector/ Ultrasound Detector	★★	$$$
TVA (Flame Ionization Detector)	★	$$$
Calibrated Bagging	★	$$
High Volume Sampler	★★★	$$$
Rotameter	★★	$$
Infrared Leak Detection	★★★	$$$
Source: EPA's Lessons Learned		

* - Least effective at screening/measurement

*** - Most effective at screening/measurement

$ - Smallest capital cost

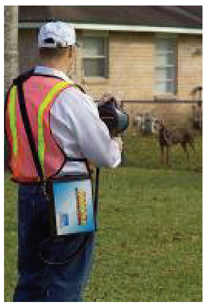
$$$ - Largest capital cost

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 Leak Detection

Source: Leak Surveys Inc.

Infrared Methane Leak Detection

- Video recording of fugitive leaks detected by various infrared devices

Is Recovery Profitable?

Repair the Cost-Effective Components			
Component	**Value of lost gas[1] ($)**	**Estimated repair cost ($)**	**Payback (months)**
Plug Valve: Valve Body	29,498	200	0.1
Union: Fuel Gas Line	28,364	100	0.1
Threaded Connection	24,374	10	0.0
Distance Piece: Rod Packing	17,850	2,000	1.4
Open-Ended Line	16,240	60	0.1
Compressor Seals	13,496	2,000	1.8
Gate Valve	11,032	60	0.1

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?