Producer Best Management Practices

Lessons Learned from the
Natural Gas STAR Program

EnCana Oil and Gas Inc.,
The Petroleum Association of Wyoming, and
The Independent Petroleum Association of Mountain States

Producers Technology Transfer Workshop
Rock Springs, WY
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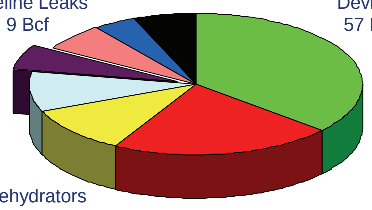
epa.gov/gasstar

Best Management Practices: Agenda

- Plunger Lifts and Smart Automation Well Venting
  - Methane Losses
  - Methane Savings
  - Is Recovery Profitable?
  - Industry Experience
- Compressors
  - Methane Losses
  - Methane Savings
  - Is Recovery Profitable?
  - Industry Experience
- Discussion

Methane Losses

- 395,000 natural gas and condensate wells (on and offshore) in the U.S.[1]
- Blow-downs to unload fluids can vent 80 to 1,600 Mcf/year[2] to the atmosphere per well
- 9 billion cubic feet (Bcf)/year from onshore well venting[1]



1 - Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2005
2 - Mobil Big Piney Case Study 1997

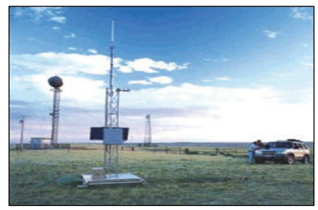
Liquid Unloading

- Accumulation of liquid hydrocarbons or water in the well bores reduces, and can halt, production

Source: BP

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

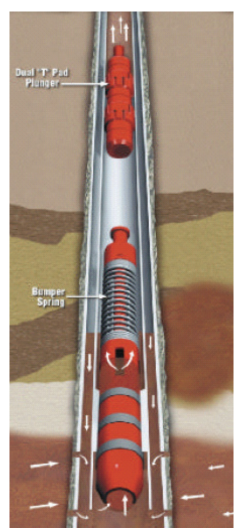


Source: BP

4

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

5

Smart Automation Well Venting

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters such as:
  - Tubing and casing pressure
  - Flow rate
  - Plunger travel time
- Using this information, the system is able to optimize plunger operations
  - To minimize well venting to atmosphere
  - Recover more gas
  - Further reduce methane emissions

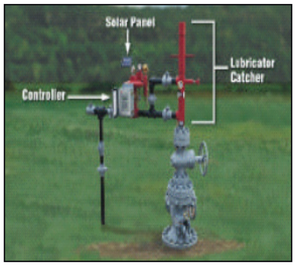
6

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

7

Automated Controllers

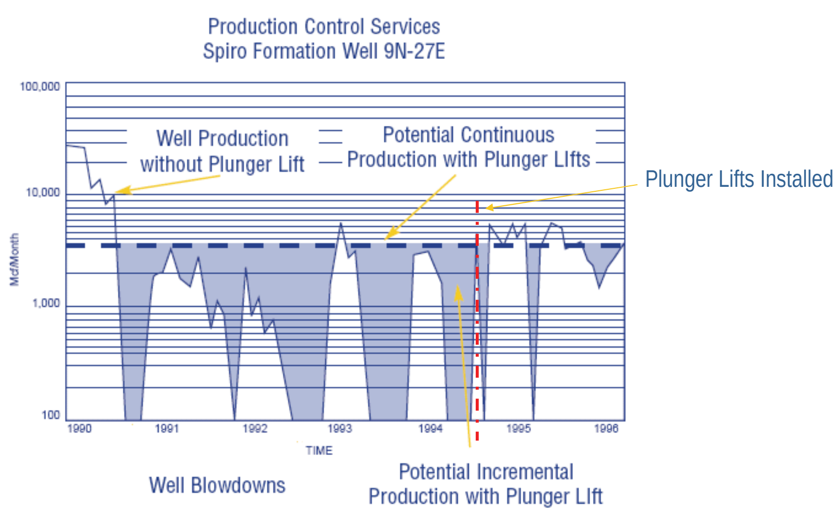


Source: Weatherford

- 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



Methane Savings

- 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

Source: BP

1 - Reported by Weatherford

10

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

Source: BP

11

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

12

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

13

BP Experience

- BP's first automation project designed and funded in 2000
- Pilot installations and testing in 2000
  - Installed plunger lifts with automated control systems on ~2,200 wells
  - ~$15,000 per well Remote Terminal Unit (RTU) installment cost
  - $50,000 - $750,000 host system installment cost
- Achieved roughly 50% reduction in venting from 2000 to 2004

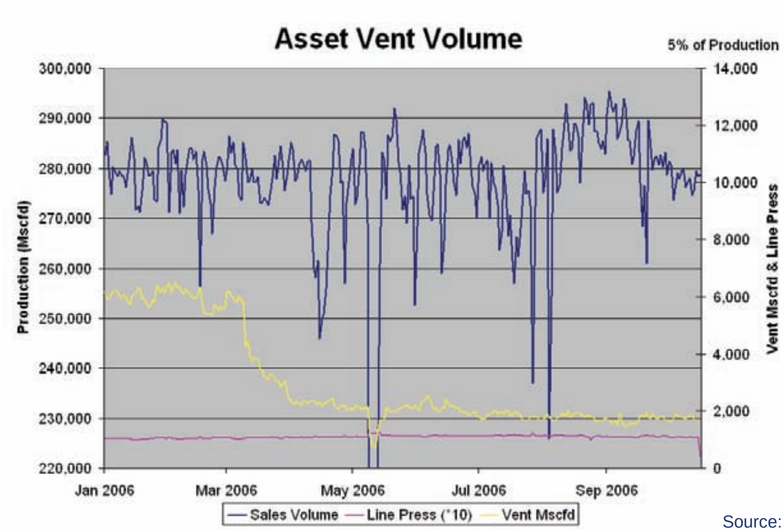
14

BP Experience

- BP designed two pilot studies in 2006 to further improve well scientific control
  - Interviewed control room staff and worked closely with the field automation team leader
  - Established a new procedure based on plunger lift expertise and pilot well analysis
- In mid 2006, "smarter" automation was applied to wells
  - 1,424 Mcf reported annual savings per well

15

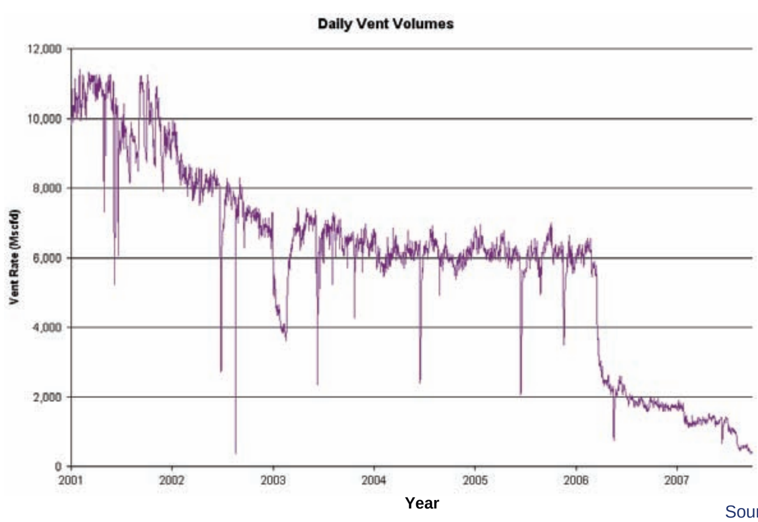
BP Experience



Source: BP

16

BP Experience



Source: BP

17

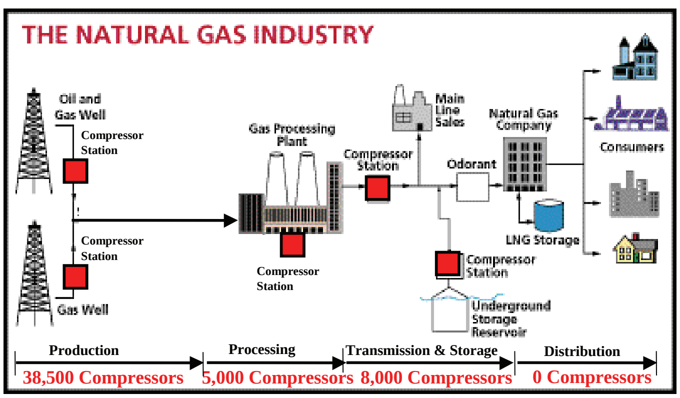
Compressors: Agenda

- Compressors
  - Methane Losses
  - Methane Savings
  - Is Recovery Profitable?
  - Industry Experience

18

Compressor Methane Emissions What is the problem?

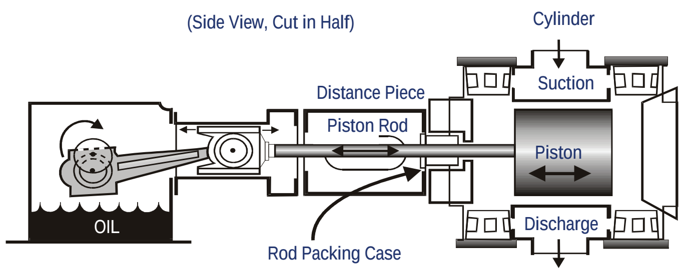
- Methane emissions from the ~51,500 compressors in the natural gas industry account for 89 Bcf/year or about 24% of all methane emissions from the natural gas industry



19

Methane Losses from Reciprocating Compressors

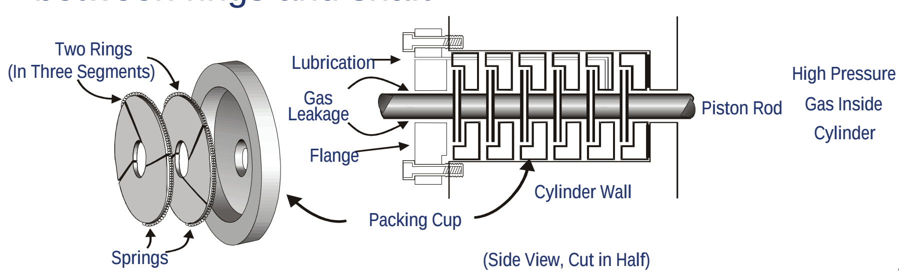
- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour)
  - Worn packing has been reported to leak up to 900 cf/hour



20

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



21

Impediments to Proper Sealing

Ways packing case can leak

- Nose gasket (no crush)
- Packing to rod (surface finish)
- Packing to cup (lapped surface)
- Packing to packing (dirt/lube)
- Cup to cup (out of tolerance)

What makes packing leak?

- Dirt or foreign matter (trash)
- Worn rod (.0015”/per inch dia.)
- Insufficient/too much lubrication
- Packing cup out of tolerance (≤ 0.002”)
- Improper break-in on startup
- Liquids (dilutes oil)
- Incorrect packing installed (backward or wrong type/style)

Methane Losses from Rod Packing

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*

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

24

Cost of Rod Packing Replacement

- Assess costs of replacements

A set of rings:	$ 135	to	$ 1,080
(with cups and case)	$ 1,350	to	$ 2,500
Rods:	$ 2,430	to	$13,500

    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO

25

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)**

26

Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement

CR = $1,620 for rings + $9,450 for rod
= $11,070
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

$$ER = \frac{\$11{,}070 \times 1.1 \times 1{,}000}{(8{,}000 \times \$7)}$$

$$= 217 \text{ scf per hour}$$

27

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)
61	6
32	12
17	24
12	36

Rod and Rings

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

Leak Reduction Expected (cf/hour)	Payback (months)
415	6
217	12
114	24
75	36

Based on 10% interest rate
Mcf = thousand cubic feet

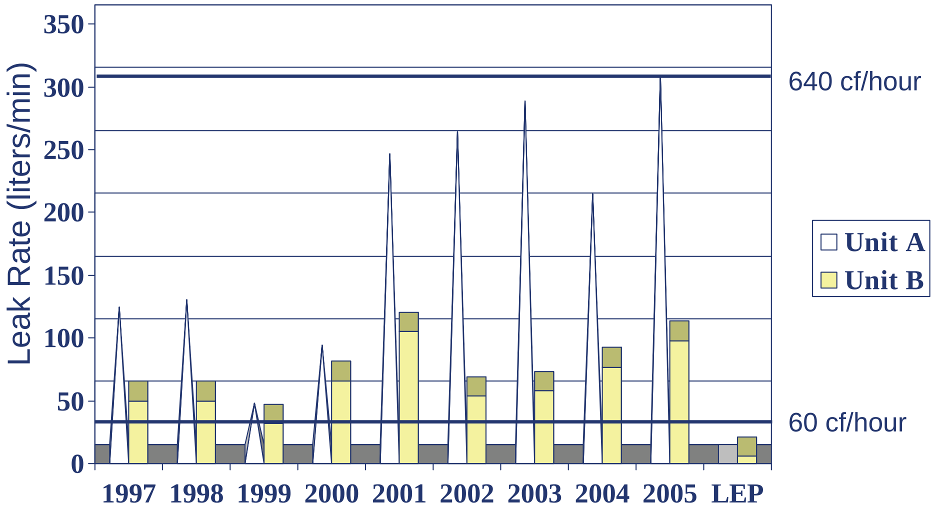
28

Industry Experience – Northern Natural Gas

- Monitored emission at two locations
  - Unit A leakage as high as 301 liters/min (640 cf/hour)
  - Unit B leakage as high as 105 liters/min (220 cf/hour)
- Installed Low Emission Packing (LEP)
  - Testing is still in progress
  - After 3 months, leak rate shows zero leakage increase

29

Northern Natural Gas - Leakage Rates



30

Northern Natural Gas Packing Leakage Economic Replacement Point

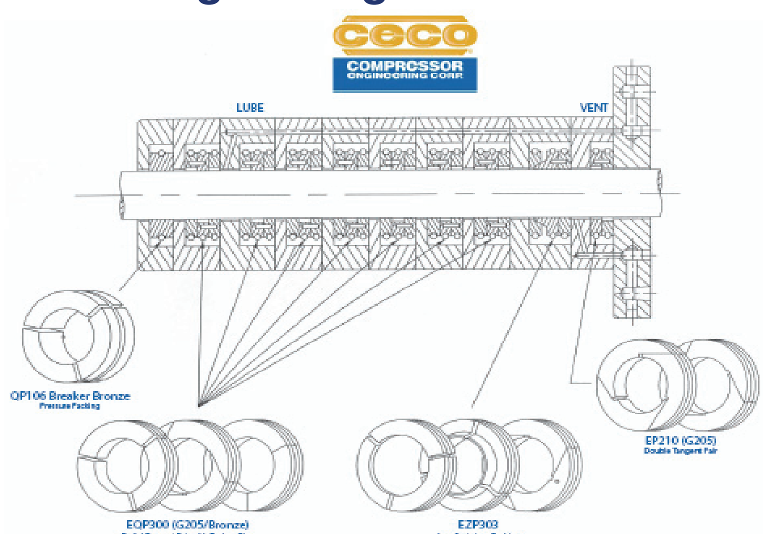
- Approximate packing replacement cost is $3,000 per compressor rod (parts/labor)
- Assuming gas at $7/Mcf:
  1 cubic foot/minute = 28.3 liters/minute
  - 50 liters/minute/28.316 = 1.8 scf/minute
  - 1.8 x 60 minutes/hour= 108 scf/hr
  - 108 x 24/1000 = 2.6 Mcf/day
  - 2.6 x 365 days= 950 Mcf/year
  - 950 x $7/Mcf = $6,650 per year leakage
  - This replacement pays back in <6 months

31

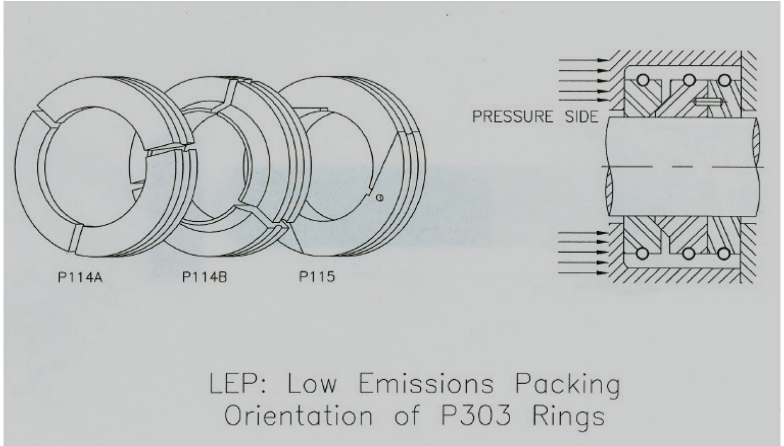
Low Emission Packing

- Low emission packing (LEP) overcomes low pressure to prevent leakage
- The side load eliminates clearance and maintains positive seal on cup face
- LEP is a static seal, not a dynamic seal. No pressure is required to activate the packing
- This design works in existing packing case with limited to no modifications required

LEP Packing Configuration



Orientation in Cup



34

Reasons to Use LEP

- Upgrade is inexpensive
- Significant reduction of greenhouse gas are major benefit
- Refining, petrochemical and air separation plants have used this design for many years to minimize fugitive emissions
- With gas at $7/Mcf, packing case leakage should be identified and fixed.

35

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?

36