Methane Savings from Compressors

Lessons Learned from Natural Gas STAR

Producers and Processors Technology Transfer Workshop

ConocoPhillips and EPA's Natural Gas STAR Program
Kenai, AK
May 25, 2006

1

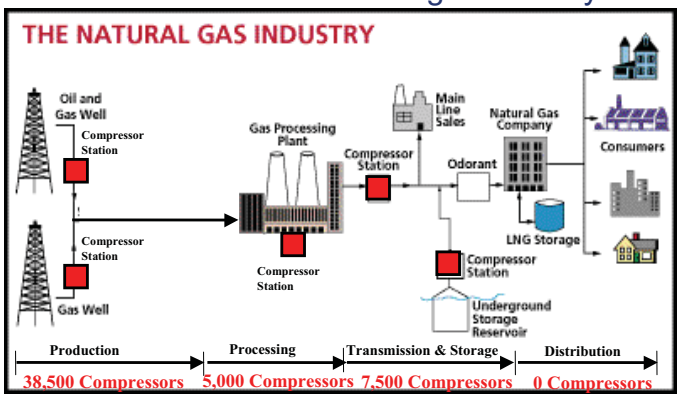
Compressors: Agenda

- Methane Losses from Reciprocating Compressors
- Methane Savings through Economic Rod Packing Replacement
- Is Rod Packing Replacement Profitable?
- Methane Losses from Centrifugal Compressors
- Methane Savings through Dry Seals
- Is Wet Seal Replacement Profitable?
- Discussion Questions

2

Compressor Methane Emissions What is the problem?

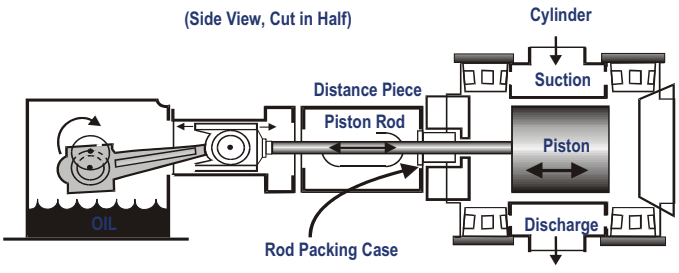
- Methane emissions from the ~51,000 compressors in the natural gas industry account for 86 Bcf/yr or about 24% of all methane emissions from the natural gas industry



3

Methane Losses from Reciprocating Compressors

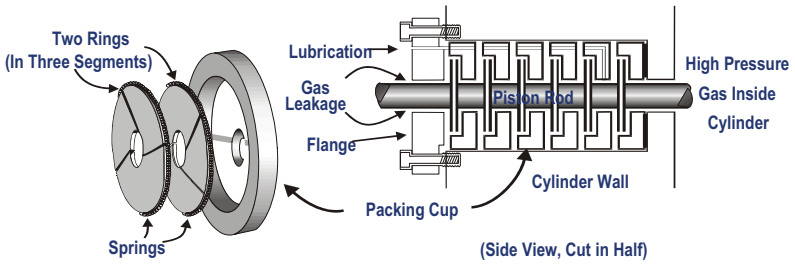
- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hr)
  - Worn packing has been reported to leak up to 900 cf/hr



4

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



5

Methane Losses from Rod Packing

Emission from Running Compressor	870	Mcf/year-packing
Emission from Idle/Pressurized Compressor	1270	Mcf/year-packing
Leakage from Packing Cup	690	Mcf/year-packing
Leakage from Distance Piece	300	Mcf/year-packing

Leakage from Rod Packing on Running Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (Mcf/yr)	612	554	1317	210

Leakage from Rod Packing on Idle/Pressurized Compressors				
Packing Type	Bronze	Bronze/Steel	Bronze/Teflon	Teflon
Leak Rate (Mcf/yr)	614	N/A	1289	191

Source: Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations – PRCI/ GRI/ EPA

6

Methane Savings Through Economic Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $ 500 to $ 800
    (with cups and case) $1500 to $2500
  - Rods: $1800 to $10000
    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs
  - Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements

$$\text{Economic Replacement Threshold (scfh)} = \frac{CR * DF * 1{,}000}{(H * GP)}$$

Where:

CR = Cost of replacement ($)
DF = Discount factor (%) @ interest *i*
H = Hours of compressor operation per year
GP = Gas price ($/Mcf)

$$DF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

7

Is Rod Packing Replacement Profitable?

- Periodically measure leakage increase

Rings Only		Rod and Rings	
Rings:	$1,200	Rings:	$1,200
Rod:	$0	Rod:	$7,000
Gas:	$7/Mcf	Gas:	$7/Mcf
Operating:	8,000 hrs/yr	Operating:	8,000 hrs/yr

Leak Reduction Expected (scfh)	Payback (yr)
46	0.5
24	1.0
12	2.0
9	3.0

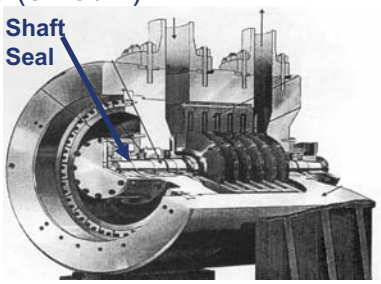
Leak Reduction Expected (scfh)	Payback (yr)
315	0.5
161	1.0
84	2.0
59	3.0

Based on 10% interest rate
Mcf = thousand cubic feet, scfh = standard cubic feet per hour

8

Methane Losses from Centrifugal Compressors

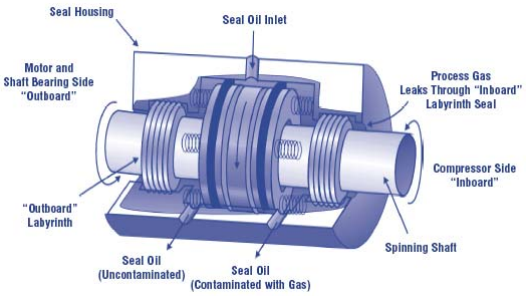
- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cubic feet per minute (cf/m) to the atmosphere
  - A Natural Gas STAR partner reported wet seal emissions of 75 Mcf/day (52 cf/m)



9

Centrifugal Compressor Wet Seals

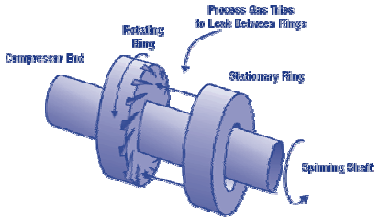
- High pressure seal oil circulates between rings around the compressor shaft
- Gas absorbs in the oil on the inboard side
- Little gas leaks through the oil seal
- Seal oil degassing vents methane to the atmosphere



10

Gas STAR Partners Reduce Emissions with Dry Seals

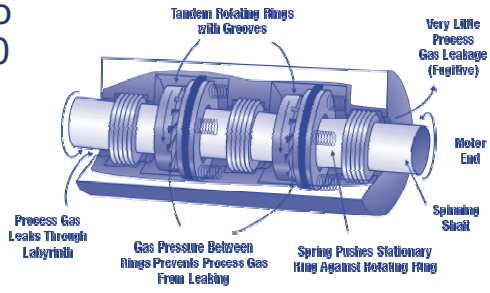
- Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- At high rotation speed, gas is pumped between the seal rings creating a high pressure barrier to leakage
- Only very small amount of gas escapes through gap
- 2 seals often used in tandem
- Can operate for compressors up to 3,000 psig safely



11

Methane Savings through Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cf/m
  - Significantly less than the 40 to 200 cf/m emissions from wet seals
- Gas savings translate to approximately $112,000 to $651,000 at $7/Mcf



12

Economics of Replacing Seals

- Compare costs and savings for a 6-inch shaft beam compressor

Cost Category	Dry Seal ($)	Wet Seal ($)
Implementation Costs[1]		
Seal costs (2 dry @ $10,000/shaft-inch, w/testing)	$120,000	
Seal costs (2 wet @ $5,000/shaft-inch)		$60,000
Other costs (engineering, equipment installation)	$120,000	$0
Total Implementation Costs	$240,000	$60,000
Annual O&M	$10,000	$73,000
Annual Methane Emissions (@ $7/Mcf; 8,000 hr/yr)		
2 dry seals at a total of 6 scfm	$20,160	
2 wet seals at a total of 100 scfm		$336,000
Total Costs Over 5-Year Period	$390,800	$2,105,000
Total Dry Seal Savings Over 5 Years		
Savings	$1,714,200	
Methane Emissions Reductions (Mcf; at 45,120 Mcf/yr)	225,600	

[1] **Flowserve Corporation**

13

Is Wet Seal Replacement Profitable?

- Replacing wet seals in a 6 inch shaft beam compressor operating 8,000 hr/yr
  - Net Present Value = $1,216,000
    - Assuming a 10% discount over 5 years
  - Internal Rate of Return = 171%
  - Payback Period = 7 months
    - Ranges from 4 to 15 months based on wet seal leakage rates between 40 and 200 cf/m
- Economics are better for new installations
  - Vendors report that 90% of compressors sold to the natural gas industry are centrifugal with dry seals

14

Discussion Questions

- To what extent are you implementing these opportunities?
- How could these opportunities be improved upon or altered for use in your operation?
- Can you suggest other methods for reducing emissions from compressors?
- What are the barriers (technological, economic, lack of information, regulatory, focus, manpower, etc.) that are preventing you from implementing these practices?

15