Methane to Markets

Compressor Best Practices

Technology Transfer Workshop

PEMEX &
Environmental Protection Agency, USA

April 25, 2006
Villahermosa, Mexico

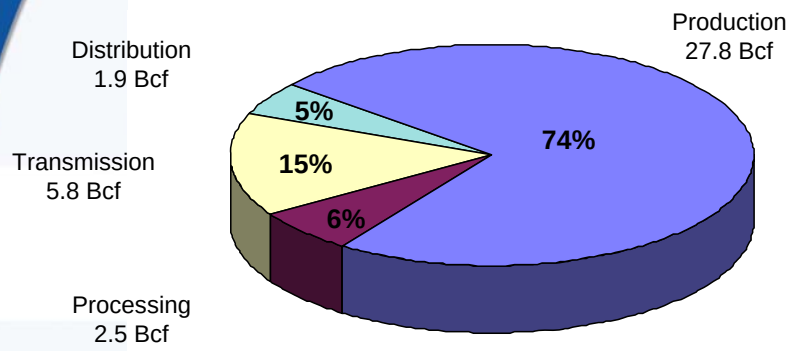
Methane to Markets

Compressors: Agenda

- Methane Losses from Oil and Gas Industry
- 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?
- Project Summary for Mexico
- Discussion Questions

2

Mexico Oil and Gas Methane Emissions in 2000



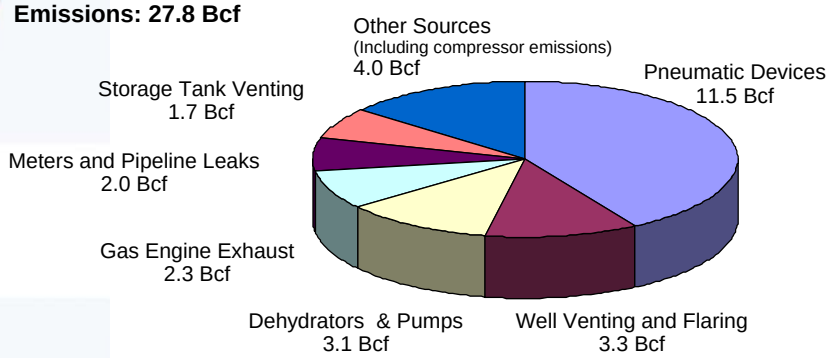
Sources: *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004

Bcf = billion cubic feet

3

Mexico Production Sector Methane Emissions (2000)

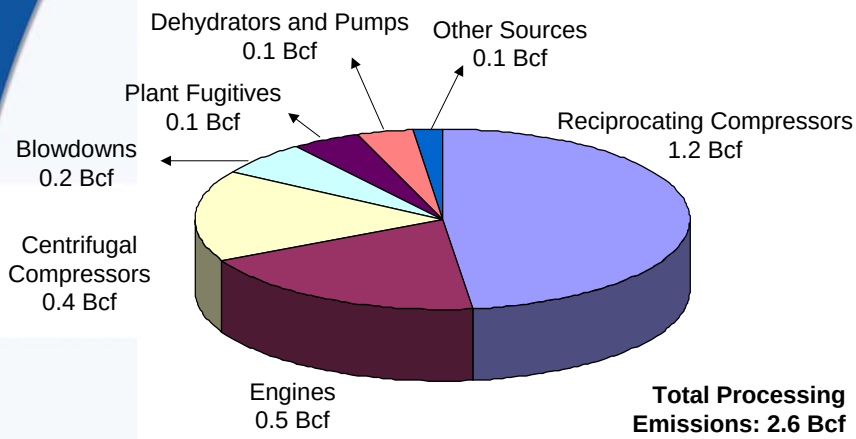
Total Production Emissions: 27.8 Bcf



Sources: *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004

4

Mexico Processing Sector Methane Emissions (2000)



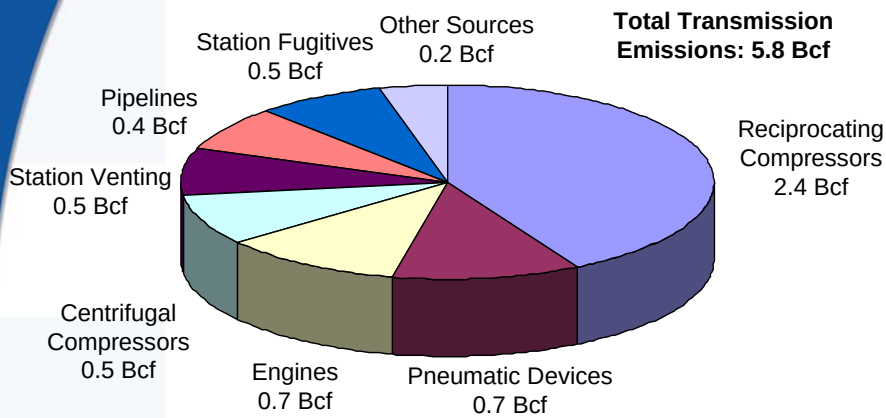
Total Processing Emissions: 2.6 Bcf

Sources: *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004

5

Mexico Transmission Sector Methane Emissions (2000)

Total Transmission Emissions: 5.8 Bcf

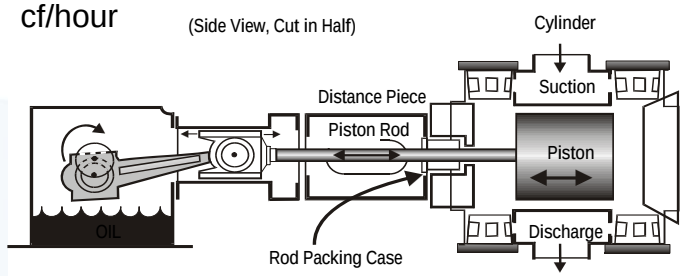


Sources: *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004

6

Methane Losses from Reciprocating Compressors

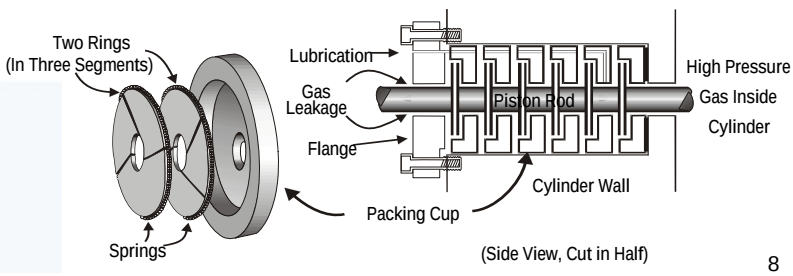
- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour)
  - Worn packing has been reported to leak up to 900 cf/hour



7

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



8

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/year)	612	554	1317	210

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

Source: Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations – PRCI/ GRI/ EPA PR-246-9526

Mcf/year = Thousand cubic feet per year
35 cubic feet is about 1 cubic meter

9

Methane Savings Through 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

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

Where:

CR = Cost of Replacement ($)
DF = Discount factor (%) at interest *i*
H = Hours of compressor operation per year
GP = Gas price ($ per thousand cubic feet)

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

10

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 per Mcf	Gas:	$7 per Mcf
Operating:	8,000 hours per year	Operating:	8,000 hours per year

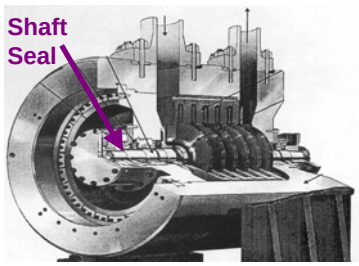
Leak Reduction Expected (cf/hour)	Payback (years)
32	0.67
17	1.3
9	2.4
6	3.6

Leak Reduction Expected (cf/hour)	Payback (years)
220	0.67
113	1.3
59	2.5
41	3.6

11

Methane Losses from Centrifugal Compressors

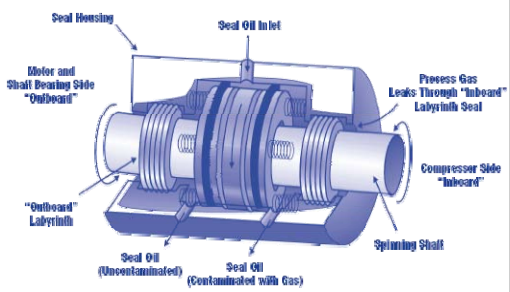
- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cf/minute to the atmosphere
  - A U.S. company reported wet seal emissions of 75,000 cubic feet per day (52 cf/minute)



12

Centrifugal Compressor Wet Seals

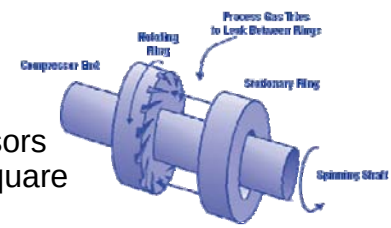
- High pressure seal oil circulates between rings around the compressor shaft
- Gas absorbs in the oil on the inboard side
- Little gas leaks through the oil seal
- Seal oil degassing vents methane to the atmosphere



13

U.S. Companies Reduce Emissions with Dry Seals

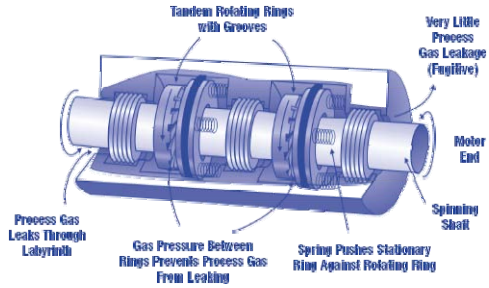
- Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- At high rotation speed, gas is pumped between the seal rings creating a high pressure barrier to leakage
- Only a very small amount of gas escapes through the gap
- 2 seals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



14

Methane Savings through Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cf/minute
  - Significantly less than the 40 to 200 cf/minute emissions from wet seals
- Gas savings translate to approximately $112,000 to $651,000 at $7 per thousand cubic feet gas price



15

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 at $10,000 per shaft-inch, with testing)	$120,000	
Seal costs (2 wet at $5,000 per shaft-inch)		$60,000
Other costs (engineering, equipment installation)	$120,000	$0
Total Implementation Costs	$240,000	$60,000
Annual Operation & Maintenance	$10,000	$73,000
Annual Methane Emissions (at $7 per Mcf; 8,000 hours per year)		
2 dry seals at a total of 6 cubic feet per minute	$20,160	
2 wet seals at a total of 100 cubic feet per minute		$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 (45,120 Mcf per year)	315,840	

1 - Flowserve Corporation

16

Is Wet Seal Replacement Profitable?

- Replacing wet seals in a 6 inch shaft beam compressor operating 8,000 hours per year
  - 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 16 months based on wet seal leakage rates between 40 and 200 cf/minute
- Economics are better for new installations

17

Project Summary for Mexico

- Replace reciprocating compressor rod packing

Project Description: Replace rods and rings on a reciprocating compressor	
Methane Saved:	865 Mcf per year (24.5 thousand cubic meters per year)
Sales Value:	$4,500 ($5.25 per Mcf gas)
Capital and Installation Cost:	($8,200) for rods and rings
Operating and Maintenance Cost:	($100) per year
Payback Period:	22 months

Additional Carbon Market Value:	$10,500 ($30 per tonne of CO_2e)

18

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Project Summary for Mexico

- Replace centrifugal compressor wet seals with dry seals

Project Description: Replace wet seals with dry seals for a 6-inch shaft beam compressor	
Methane Saved:	45,120 Mcf per year (1,277 thousand cubic meters per year)
Sales Value:	$237,000 ($5.25 per Mcf gas)
Capital and Installation Cost[1]:	($240,000)
Operating and Maintenance Cost[2]:	($2,600) per year
Payback Period:	12 months

Additional Carbon Market Value:	$547,000 ($30 per tonne of CO_2e)

1 - $180,000 capital cost increase over wet seals
2 - $63,000 annual operating cost decrease over wet seals

19

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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?

Reference: Unit Conversions

1 cubic foot =	0.02832 cubic meters
Degrees Fahrenheit =	(°F – 32) * 5/9 degrees Celsius
1 inch =	2.54 centimeters
1 mile =	1.6 kilometers
14.7 pounds per square foot =	1 atmosphere

20