

# Methane Savings from Compressors

Lessons Learned  
from Natural Gas STAR

Producers and Processors  
Technology Transfer Workshop

Western Gas Resources and  
EPA's Natural Gas STAR Program  
Gillette and Rock Springs, WY  
May 9 & 11, 2006

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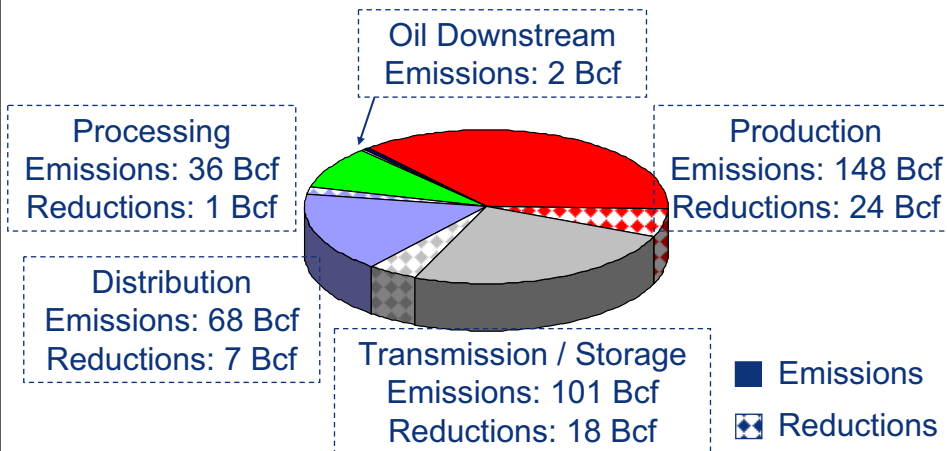


## Compressors: Agenda

- 🔥 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

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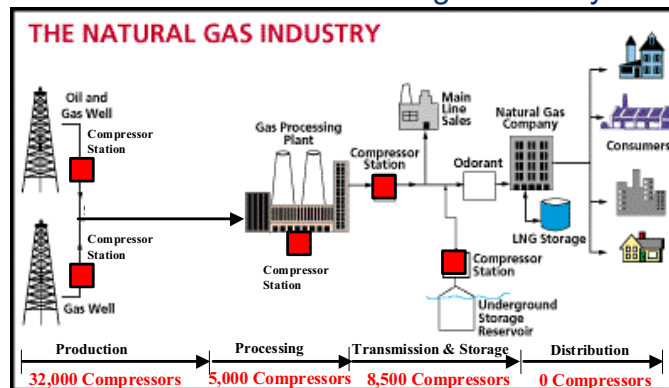
## Oil & Gas Methane Emissions Without Gas STAR Program (2003)



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## Compressor Methane Emissions What is the problem?

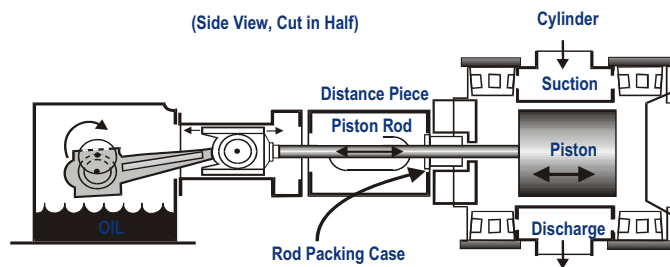
- ⚡ Methane emissions from the ~45,000 compressors in the natural gas industry account for 86 Bcf/yr or about 28% of all methane emissions from the natural gas industry



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## Methane Losses from Reciprocating Compressors

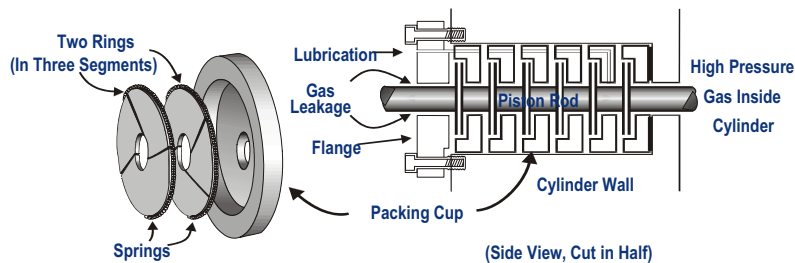
- ⚡ Reciprocating compressor rod packing leaks some gas by design
  - ⚡ Newly installed packing may leak 60 cubic feet per hour (cf/hr)
  - ⚡ Worn packing has been reported to leak up to 900 cf/hr



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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

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

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## 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

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

Where:

CR = Cost of replacement (\$)

DF = Discount factor (%) @ interest *i*

H = Hours of compressor operation per year

GP = Gas price (\$/Mcf)

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

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## 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

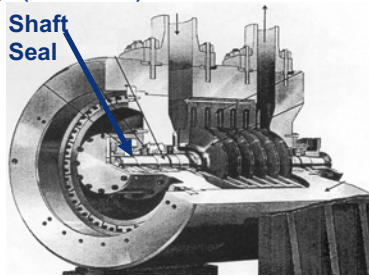
Leak Reduction Expected (scfh)	Payback (yr)
315	0.5
161	1.0
84	2.0
59	3.0

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

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## Methane Losses from Centrifugal Compressors

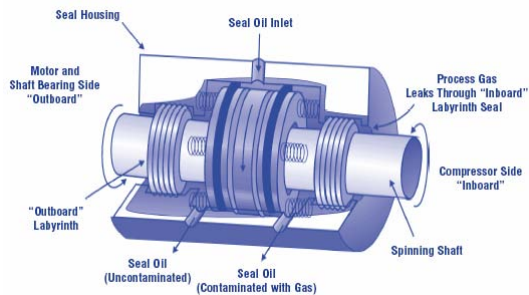
- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cubic feet per minute (cf/m) to the atmosphere
  - A Natural Gas STAR partner reported wet seal emissions of 75 Mcf/day (52 cf/m)



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## Centrifugal Compressor Wet Seals

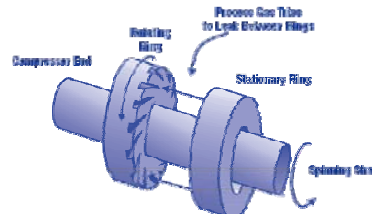
- 🔥 High pressure seal oil circulates between rings around the compressor shaft
- 🔥 Gas absorbs in the oil on the inboard side
- 🔥 Little gas leaks through the oil seal
- 🔥 Seal oil degassing vents methane to the atmosphere



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## Gas STAR Partners Reduce Emissions with Dry Seals

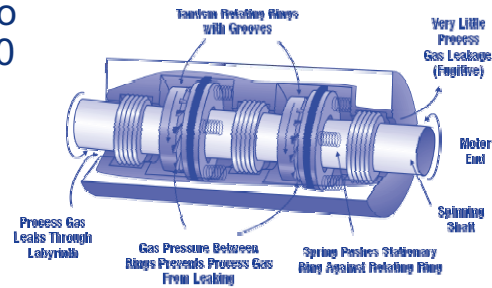
- 🔥 Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- 🔥 At high rotation speed, gas is pumped between the seal rings creating a high pressure barrier to leakage
- 🔥 Only very small amount of gas escapes through gap
- 🔥 2 seals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



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## 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



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## Economics of Replacing Seals

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

Cost Category	Dry Seal (\$)	Wet Seal (\$)
<b>Implementation Costs<sup>1</sup></b>		
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
<b>Total Implementation Costs</b>	<b>\$240,000</b>	<b>\$60,000</b>
<b>Annual O&amp;M</b>	<b>\$10,000</b>	<b>\$73,000</b>
<b>Annual Methane Emissions (@ \$7/Mcf; 8,000 hr/yr)</b>		
2 dry seals at a total of 6 scfm	\$20,160	
2 wet seals at a total of 100 scfm		\$336,000
<b>Total Costs Over 5-Year Period</b>	<b>\$390,800</b>	<b>\$2,105,000</b>
<b>Total Dry Seal Savings Over 5 Years</b>		
Savings	\$1,714,200	
Methane Emissions Reductions (Mcf; at 45,120 Mcf/yr)	225,600	

<sup>1</sup> Flowserve Corporation

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## 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

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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?

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