

Methane Savings from Compressors

Lessons Learned
from Natural Gas STAR

Producers and Processors
Technology Transfer Workshop

New Mexico Oil and Gas Association and
EPA's Natural Gas STAR Program
Farmington, NM
February 21, 2006

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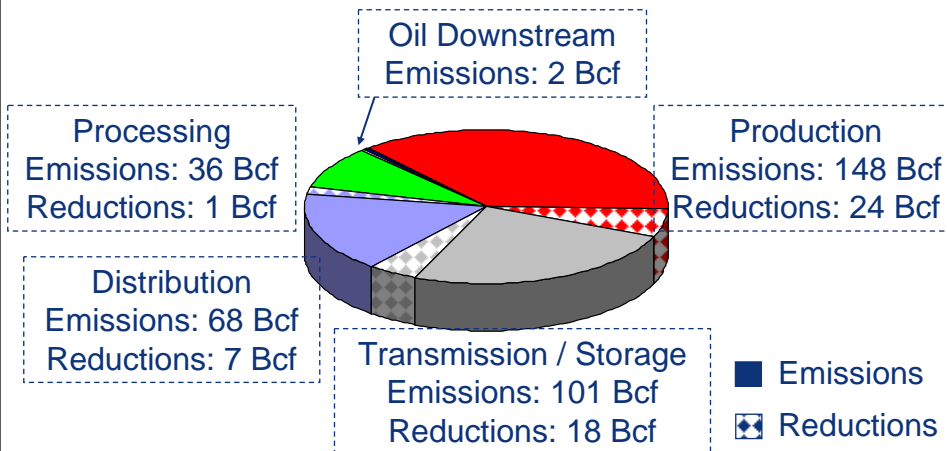


Compressors: Agenda

- 🔥 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?
- 🔥 Directed Inspection and Maintenance (DI&M) at Compressor Stations
- 🔥 Discussion Questions

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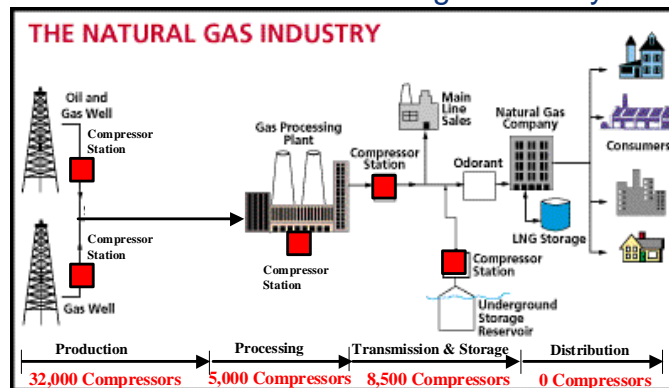
Oil & Gas Methane Emissions Without Gas STAR Program (2003)



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Compressor Methane Emissions What is the problem?

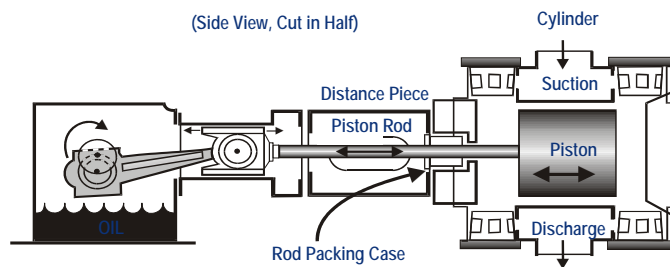
- Methane emissions from the ~45,000 compressors in the natural gas industry account for 86 Bcf/yr or about 28% of all methane emissions from the natural gas industry



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Methane Losses from Reciprocating Compressors

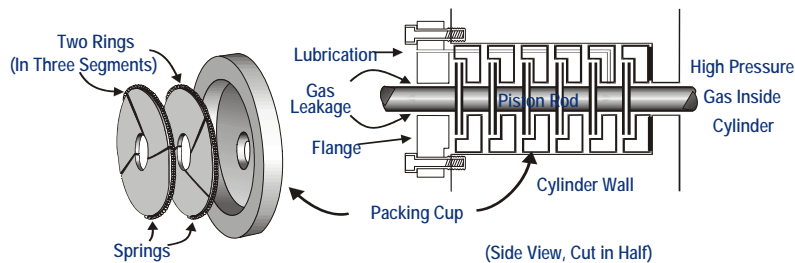
- ⚡ Reciprocating compressor rod packing leaks some gas by design
 - ⚡ Newly installed packing may leak 60 cubic feet per hour (cf/hr)
 - ⚡ Worn packing has been reported to leak up to 900 cf/hr



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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:	\$10/Mcf	Gas:	\$10/Mcf
Operating:	8,000 hrs/yr	Operating:	8,000 hrs/yr

Leak Reduction Expected (scfh)	Payback (yr)
32	0.5
17	1.0
9	2.0
6	3.0

Leak Reduction Expected (scfh)	Payback (yr)
220	0.5
113	1.0
59	2.0
41	3.0

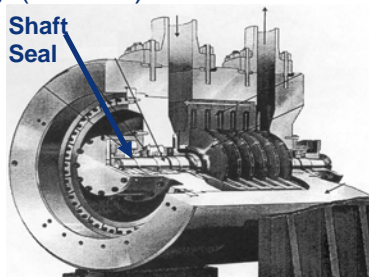
Based on 10% interest rate
Mcf = thousand cubic feet, scfh = standard cubic feet per hour

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Methane Losses from Centrifugal Compressors

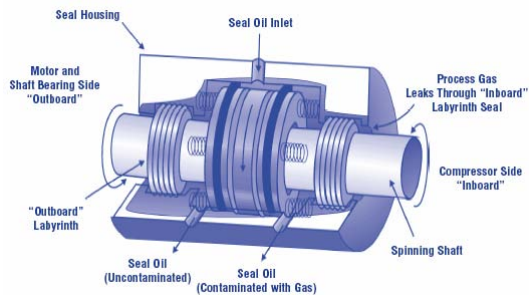
- Centrifugal compressor wet seals leak little gas at the seal face
 - Seal oil degassing may vent 40 to 200 cubic feet per minute (cf/m) to the atmosphere
 - A Natural Gas STAR partner reported wet seal emissions of 75 Mcf/day (52 cf/m)



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Centrifugal Compressor Wet Seals

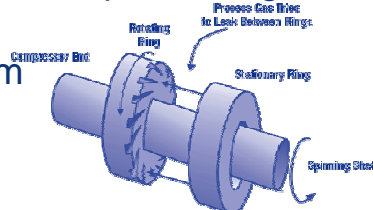
- 🔥 High pressure seal oil circulates between rings around the compressor shaft
- 🔥 Gas absorbs in the oil on the inboard side
- 🔥 Little gas leaks through the oil seal
- 🔥 Seal oil degassing vents methane to the atmosphere



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Gas STAR Partners Reduce Emissions with Dry Seals

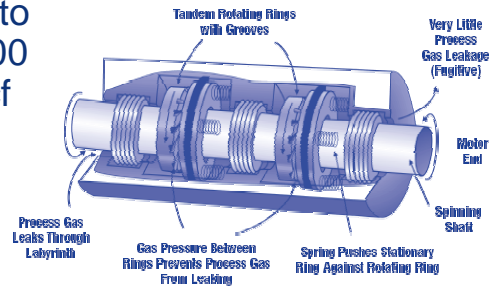
- 🔥 Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- 🔥 At high rotation speed, gas is pumped between the seal rings creating a high pressure barrier to leakage
- 🔥 Only a very small amount of gas escapes through the gap
- 🔥 2 seals are often used in tandem
- 🔥 Can operate for compressors up to 3,000 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 \$160,000 to \$930,000 at \$10/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 (\$)
Implementation Costs¹		
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 (@ \$10/Mcf; 8,000 hr/yr)		
2 dry seals at a total of 6 scfm	\$28,800	
2 wet seals at a total of 100 scfm		\$480,000
Total Costs Over 5-Year Period	\$434,000	\$2,825,000
Total Dry Seal Savings Over 5 Years		
Savings	\$2,391,000	
Methane Emissions Reductions (Mcf; at 45,120 Mcf/yr)	225,600	

¹ 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 = \$1,729,000
 - 💧 Assuming a 10% discount over 5 years
 - 💧 Internal Rate of Return = 233%
 - 💧 Payback Period = 6 months
 - 💧 Ranges from 3 to 13 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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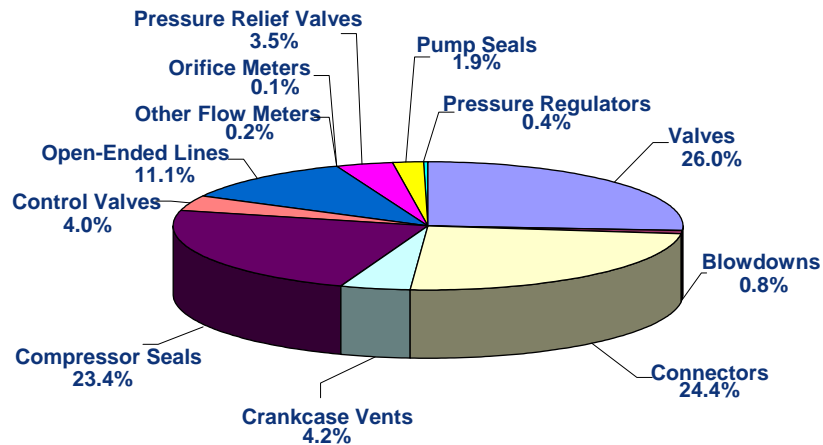
Directed Inspection and Maintenance at Compressor Stations

- 💧 What is the problem?
 - 💧 Gas leaks are invisible, unregulated and go unnoticed
- 💧 Gas STAR partners find that valves, connectors, compressor seals and open-ended lines (OELs) are major sources
- 💧 Facility fugitive methane emissions depend on operating practices, equipment age and maintenance

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Natural Gas Losses by Equipment Type



Clearstone Engineering, 2002

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Methane Losses

Summary of Natural Gas Losses from the Top Ten Leakers ¹				
Plant No.	Gas Losses From Top 10 Leakers (Mcf/d)	Gas Losses From All Equipment Leakers (Mcf/d)	Contribution By Top 10 Leakers (%)	Percent of Plant Components that Leak
1	43.8	122.5	35.7	1.78
2	133.4	206.5	64.6	2.32
3	224.1	352.5	63.6	1.66
4	76.5	211.3	36.2	1.75
Combined	477.8	892.84	53.5	1.85

¹Excluding leakage into flare system

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How Can These Losses Be Reduced?

- Implementing a Directed Inspection and Maintenance (DI&M) Program



Clearstone Engineering, 2002

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What is a DI&M Program?

- Voluntary program to identify and fix leaks that are cost-effective to repair
- Outside of mandatory LDAR
- Survey cost will pay out in the first year
- Provides valuable data on leakers



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Screening and Measurement

Summary of Screening and Measurement Techniques		
<i>Instrument/ Technique</i>	<i>Effectiveness</i>	<i>Approximate Capital Cost</i>
Soap Solution	* *	\$
Electronic Gas Detectors	*	\$\$
Acoustic Detection/ Ultrasound Detection	* *	\$\$\$
TVA (FID)	*	\$\$\$
Bagging	*	\$\$\$
High Volume Sampler	* * *	\$\$\$
Rotameter	* *	\$\$
Infrared Detection	* * *	\$\$\$

* - Least effective at screening/measurement

\$ - Smallest capital cost

*** - Most effective at screening/measurement

\$\$\$ - Largest capital cost

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Cost-Effective Repairs

Repair the Cost Effective Components			
Component	Value of Lost Gas ¹ (\$)	Estimated Repair Cost (\$)	Payback (Months)
Plug Valve: Valve Body	42,137	200	0.1
Union: Fuel Gas Line	40,517	100	0.0
Threaded Connection	34,820	10	0.0
Distance Piece: Rod Packing	25,496	2,000	0.9
Open-Ended Line	23,197	60	0.0
Compressor Seals	19,276	2,000	1.2
Gate Valve	15,763	60	0.0

¹Based on \$10/Mcf gas price

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How Much Gas Can Be Saved?

- ⦿ Natural Gas STAR Lessons Learned study for DI&M at compressor stations estimates
 - ⦿ Potential Average Gas Savings ~ 29,000 Mcf/yr/compressor station
 - ⦿ Value of gas saved ~ \$290,000 per compressor station (at gas price of \$10/Mcf)
 - ⦿ Average initial implementation cost ~ \$26,000 per compressor station

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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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