Methane Savings from Compressors

Lessons Learned from Natural Gas STAR Program

Source Reduction Training

Interstate Oil and Gas Compact Commission

Charleston, West Virginia
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epa.gov/gasstar

Compressors: Agenda

- Methane Losses from Reciprocating Compressors
- Methane Savings through Economic Rod Packing Replacement
- Is Rod Packing Replacement Profitable?
- Low Emission Packing
- Industry Experience
- Lessons Learned
- Discussion

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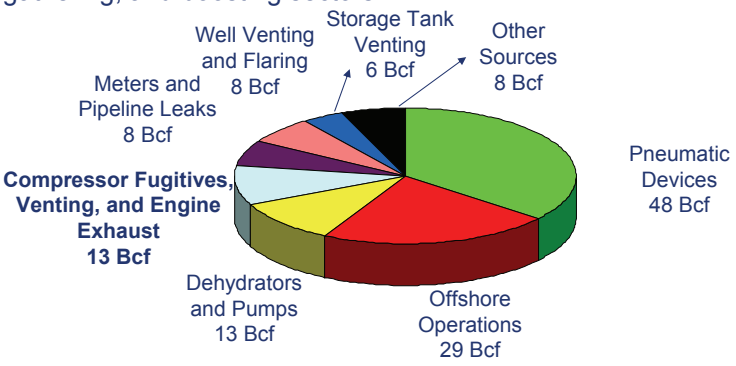
Methane Losses from Compressors

- Compressors account for:
  - 13 Billion cubic feet (Bcf) of methane emissions in the production, gathering, and boosting sectors



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2006.* April, 2008. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html
Natural Gas STAR reductions from gathering and boosting operations have been moved to the production sector.

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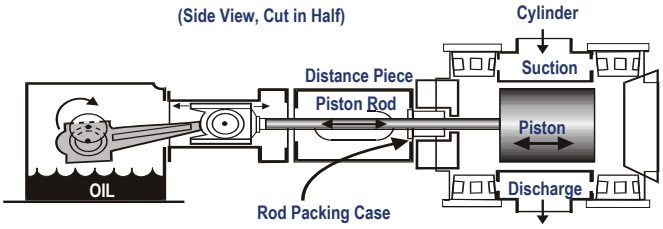
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour) in transmission compressors and 15 cf/hour in production compressors
  - Worn packing has been reported to leak up to 15 times more gas than a newly installed packing



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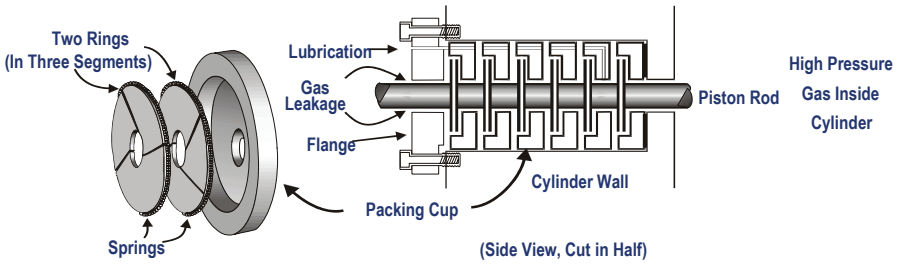
Reciprocating Compressor Rod Packing

- 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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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)

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Methane Losses from Rod Packing in Transmission Compressors

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*

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Methane Losses from Compressors

- GRI/EPA[1] reports an average leakage rate of .359 cf/hour per compressor rod packing annually in the production sector for throughputs of 0.13 to 250 million cubic feet per day (MMcf/day)
- GRI/EPA[1] reports an average leakage rate of 169 cf/hour per compressor rod packing annually in the transmission sector for throughputs of 8.9 to 843 MMcf/day
- A production compressor vendor reported emissions of 15 scf/ hour per compressor rod packing

1 GRI/EPA : Volume 8, Equipment Leaks, 1996

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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

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Cost of Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $ 325 to $530
    (with cups and case) $1,010 to $1,640
  - Rods: $1,200 to $6,510
    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO

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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)**

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Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement

CR = $492 for rings + $1,725 for rod
= $2,217
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

$$ER = \frac{\$2{,}217 \times 1.1 \times 1{,}000}{(8{,}000 \times \$7)} = 44 \text{ scf per hour}$$

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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: $492 (6 cups)
Rod: $0
Gas: $7/Mcf
Operating: 8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (year)
10	1
5	2
4	3
3	4

Rod and Rings

Rings: $ 492 (6 cups)
Rod: $1,725
Gas: $7/Mcf
Operating: 8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (year)
34	1
18	2
12	3
10	4

Based on 10% interest rate,
Mcf = thousand cubic feet

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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

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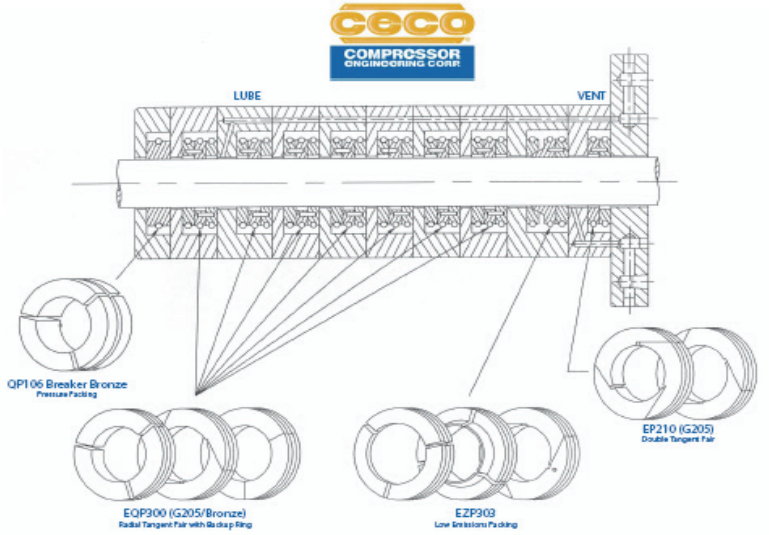
LEP Packing Configuration



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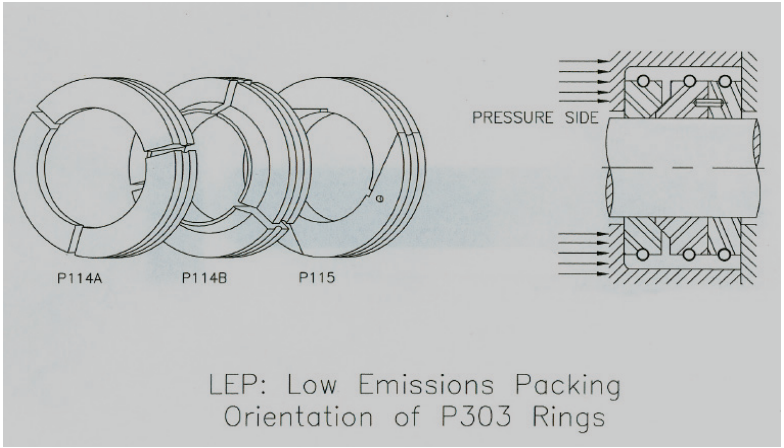
Orientation in Cup



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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.

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Industry Experience – Occidental

- Occidental upgraded compressor rod packing at its Elk Hills facility in southern California
- Savings 145 MMcf/yr
- Payback in under 3 years

Source: Occidental

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Lessons Learned

- Development of a system to regularly measure and monitor leakage from piston rod packing cases
- Regularly monitor lubrication and cooling to help reduce wear on packing rings
- Establishment of baseline initial leakage rates (IL) for new rods and new packing rings by compressor type and size
- Establishment of a company wide emission threshold for each compressor to indicate economic compressor ring packing and piston rods replacement

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Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies an practices
- Actual costs and benefits
- Leased compressors
  - Control over rod packing type and maintenance?

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