Reducing Methane Emissions from Reciprocating and Centrifugal Compressors

Oil & Gas Subcommittee Technology Transfer Workshop

January 28, 2009
Monterrey, Mexico
U.S. Processing Sector Methane Emissions

Note: Natural Gas STAR reductions from gathering and boosting operations are reflected in the production sector.
Compressor Methane Emissions
What is the problem?

- It is estimated that methane emissions from compressors in the natural gas industry account for about one fourth of all methane emissions from the natural gas industry.
Methane Savings from Compressors: Agenda

- Reciprocating Compressors
  - Methane Losses
  - Methane Savings
  - Industry Experience

- Centrifugal Compressors
  - Methane Losses
  - Methane Savings
  - Industry Experience
Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cfh
  - Worn packing has been reported to leak up to 900 cfh
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
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 (0.0015 in/in Ø)
- Insufficient/too much lubrication
- Packing cup out of tolerance (≤ 0.002mm)
- Improper break-in on startup
- Liquids (dilutes oil)
- Incorrect packing installed (backward or wrong type/style)
# Methane Losses from Rod Packing

<table>
<thead>
<tr>
<th>Methane Losses from Rod Packing</th>
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<tr>
<td>Emission from Running Compressor</td>
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<tr>
<td>Emission from Idle/Pressurized Compressor</td>
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<td>Leakage from Idle Compressor Packing Cup</td>
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<td>Leakage from Idle Compressor Distance Piece</td>
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## Leakage from Rod Packing on Running Compressors

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<tr>
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<td>Leak Rate (cfh)</td>
<td>70</td>
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## Leakage from Rod Packing on Idle/Pressurized Compressors

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<td>70</td>
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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
Cost of Rod Packing Replacement

- Assess costs of replacements (US$)
  - A set of rings: $135 to $1,080
    (with cups and case) $1,350 to $2,500
  - Rods: $2,430 to $13,500
    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO
Calculate Economic Leak Reduction

- Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements
  - This is a capital recovery economic calculation

\[
\text{Economic Replacement Threshold (cfh)} = \frac{CR \times A/P \times 1000}{(H \times GP)}
\]

- **CR** = Cost of replacement (US$)
- **A/P** = Capital recovery factor at interest *i* and *n* years recovery period
- **H** = Hours of compressor operation per year
- **GP** = Gas price (US$/Mcf)
Economic Replacement Threshold

- Example: Payback calculations for new rings and rod replacement

$$CR = \$1,620 \text{ for rings } + \$9,450 \text{ for rod}$$

$$CR = \$11,070$$

$$H = 8,000 \text{ hours per year}$$

$$GP = \$5/Mcf$$

$$A/P @ i = 10\% , n = 1 \text{ year } = 1.1$$

$$A/P @ i = 10\% , n = 2 \text{ years } = 0.576$$

Two year payback:

$$ER = \frac{\$11,070 \times 0.576 \times 1,000}{(8,000 \times \$5)}$$

$$= 159 \text{ scfh}$$
Case Study: Partner Packing Leakage Economic Replacement Point

- Approximate packing replacement cost is US$3,000 per compressor rod (parts/labor)
- Assuming gas at US$5/Mcf:
  - 1.76 cfm =
  - 1.76 x 60 minutes/hour = 105 cfh
  - 105 x 24/1,000 = 2.52 Mcf/d
  - 2.52 x 365 days = 919.8 Mcf/year
  - 919.8 x $5/Mcf = $4,599 per year leakage
  - This replacement pays back in <1 year
Methane Losses from Centrifugal Compressors

- Centrifugal compressor wet seals leak little gas at the seal face
  - Seal oil degassing may vent 40 to 200 cfm to the atmosphere
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
Emissions Reductions 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.
Methane Recovery with Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cfm
  - Significantly less than the 40 to 200 cfm emissions from wet seals

- These savings translate to approximately $88,800 to $472,800 in annual gas value
Other Benefits with Dry Seals

- Aside from gas savings and reduced emissions, dry seals also:
  - Lower operating cost
    - Dry seals do not require seal oil make-up
  - Reduced power consumption
    - Wet seals require 50 to 100 kiloWatt hours (kW/hr) for ancillary equipment while dry seals need only 5 kW/hr
  - Improve reliability
    - More compressor downtime is due to wet seals
  - Eliminate seal oil leakage into the pipelines
    - Dry seals lower drag in pipelines (and horsepower to overcome)
Case Study

- PEMEX Gas seal substitution program