Methane Emission Reductions from Reciprocating Compressors
Lessons Learned from Natural Gas STAR

EPA’s Natural Gas STAR Program,
Pioneer Natural Resources USA, Inc., and
The Gas Processors Association

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Methane Emission Reductions from Reciprocating Compressors

- Introduction to Compressors
- Methane Losses
- Steps to Reduce Methane Losses
- Cost Effectiveness
- Future Trends
Location and Types of Compressors

THE NATURAL GAS INDUSTRY

Production: 32,000 Compressors
Processing: 5,000 Compressors
Transmission & Storage: 8,500 Compressors
Distribution: 0 Compressors
Reciprocating Compressor Rod Packing Systems
Methane Losses

- Compressor seals are fourth largest emission source at 16 Bcf/yr
- Leakage typically occurs
  - Around the packing case nose gasket
  - Between the packing cups
  - Around rings from slight movement in the cup
  - Between the rings and shaft
- All packing systems normally leak
  - New systems lose ~ 60 scfh
  - Badly worn systems lose ~ 900 scfh
Steps to Reduce Methane Losses

- Leakage can be reduced through monitoring and economic replacement
  - Conventional packing rings need to be replaced every 3 to 5 years
- An economic leak rate can be determined based on costs and gas savings
- Replacing rings when it is economical
  - Saves gas and money
  - Extends the life of the compressor rod
Partners should develop an “economic replacement threshold” that defines the point when it is cost-effective to replace rings and rods.

Economic Replacement Threshold (scfh) = 

\[ \frac{(CR \times DF)}{\left[\left(\frac{H \times GP}{1,000}\right)\right]} \]

where:

- **CR** = cost of replacement ($) 
- **DF** = capital recovery 
- **H** = hours of compressor operation 
- **GP** = gas price ($/Mcf) 

\[ DF = i \left(1 + \frac{i}{m}\right)^n / \left[\left(1 + \frac{i}{m}\right)^n - 1\right] \]
# Economic Analysis

## Compressor Rod Packing System

### Economic Replacement Threshold for Packing Rings

<table>
<thead>
<tr>
<th>LRE (scfh)</th>
<th>Payback Period(^1) (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
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<td>16</td>
<td>4</td>
</tr>
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<td>13</td>
<td>5</td>
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</tbody>
</table>

\(^1\) Assumes packing ring replacement costs of $1,200, $3.00/Mcf gas and 8,000 hr/yr

### Economic Replacement Threshold for Rod and Rings

<table>
<thead>
<tr>
<th>LRE (scfh)</th>
<th>Payback Period(^1) (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>376</td>
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<tr>
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<td>2</td>
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<tr>
<td>137</td>
<td>3</td>
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<tr>
<td>108</td>
<td>4</td>
</tr>
<tr>
<td>90</td>
<td>5</td>
</tr>
</tbody>
</table>

\(^1\) Assumes packing ring replacement costs of $1,200, rod replacement cost of $7,000, $3.00/Mcf gas and 8,000 hr/yr
Partner Experience

- One partner conducted semi-annual inspections of compressor rod packing
  - Replaced packing cases at eight stations costing $1,050 per case, installed
  - Saved 55 MMcf/yr valued at $165,000
Future Trends

- Install axially loaded rings in reciprocating compressors
- Install combination rings that serve as a static seal when compressors are shut down and kept pressurized
- Vented and purged seals
Axially Loaded Rings

Source: Compressor Engineering Corporation

Reducing Emissions, Increasing Efficiency, Maximizing Profits
Three Ring Rod Packing

- Three ring rod packing is becoming more wide spread
- The rings are typically installed in one of the last two cups
- This design could be installed without any replacement or modification on the packing case cup
Discussion Questions

- To what extent are you implementing this Lesson Learned?
- How can this Lesson Learned be improved upon or altered for use in your operation(s)?
- What are the barriers (technological, economic, lack of information, regulatory, etc.) that are preventing you from implementing this technology?