Reducing Emissions from Compressor Rod Packing

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

Devon Energy Corporation and EPA’s Natural Gas STAR Program

April 20, 2005
Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions
Methane Losses from Production

- Production responsible for 42% of methane emissions

- Production: 150 Bcf
- Transmission & Storage: 98 Bcf
- Distribution: 73 Bcf
- Processing: 36 Bcf
- Oil Downstream: 25 Bcf
- 1 Bcf

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002

Reducing Emissions, Increasing Efficiency, Maximizing Profits
Methane Losses from Compressor Rod Packing

スター・Reciprocating compressors account for 2% of production sector emissions

Gas lost from rod packing is estimated to be over 350 MMcf/yr costing over $1 million (gas price of $3/Mcf)

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002

- Pneumatic Devices 60 Bcf
- Storage Tank Venting 23 Bcf
- Reciprocating Compressors 3 Bcf
- Other Sources 15 Bcf
- Meters and Pipeline Leaks 11 Bcf
- Gas Engine Exhaust 12 Bcf
- Well Venting and Flaring 12 Bcf
- Dehydrators and Pumps 14 Bcf

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002
Compressor Rod Packing
What is the Problem?

☆ Rod packing accounts for 12% of reciprocating compressor emissions in production sector

◆ Over 44,000 reciprocating compressors in natural gas industry
◆ Over 31,000 compressors in gas production sector

THE NATURAL GAS INDUSTRY

Production: 31,750 Compressors
Processing: 4,250 Compressors
Transmission & Storage: 8,000 Compressors
Distribution: 0 Compressors
Methane Losses from Rod Packing

 få Reciprocating compressor rod packing leaks some gas by design

- Newly installed packing may leak 11 cubic feet per hour (cf/h)
- Worn packing has been reported to leak up to 900 cf/h

(Side View, Cut in Half)
Reciprocating Compressor Rod Packing

- A series of flexible rings fit around the shaft to prevent leakage
- Rings held in place by springs and packing cups

Two Rings (In Three Segments)
Springs
Lubrication
Gas Leakage
Flange
Packing Cup
Cylinder Wall
Piston Rod
High Pressure
Gas Inside Cylinder
(Side View, Cut in Half)
Methane Loss Sources from Rod Packing

★ Leakage occurs
- Around packing case through nose gasket
- Between packing cups
- Around rings due to movement of the piston rod
- Between rings and piston rod

★ Leaking gases escape either through vents on the packing flange or into the distance piece

★ Leakage gradually increases from normal wear of rings and rod
Methane Recovery with Economic Rod Packing Replacement

☆ Leak rates from rod packing eventually increase to a level that economically justifies packing replacement
  ◆ Frequency of economic replacement depends on lubrication, rod alignment, rod wear, rod material and economic hurdle-rate

☆ Benefits of economic packing replacement
  ◆ Reduced methane emissions
  ◆ Gas savings with lower leakage rates
  ◆ Extended service life of compressor rods
Rod Packing Replacement Decision Process

Monitor and record baseline packing leakage and piston rod wear

Compare current leak rate to initial leak rate to determine leak reduction expected

Assess costs of replacements

Determine economic replacement threshold

Replace packing and rods where cost-effective
Establish Baseline Leaks

★ Step 1: Monitor and record baseline leakage and rod wear

◆ Measure leaks immediately after installing new seals (or new rods and seals)

◆ Monitor rods periodically for shaft dimensions and surface roughness when replacing rings
  - “Out-of-round” rod seals poorly causing uneven wear and allowing more leakage
  - It also causes uneven wear on the seals shortening the life of both seal and rod
Establish Leak Reduction Expected

☆ Step 2: Compare current leak rate to initial leak rate to determine leak reduction expected

◆ Leak Reduction Expected (LRE) = Current Leak Rate (CL) – Initial Leak Rate at the last ring/rod replacement (IL)

◆ Example: The current leak rate is measured as 50 cf/h, the same component leaked 10 cf/h when first installed

LRE = 50 cf/h – 10 cf/h
LRE = 40 cf/h
Assess Costs for Economic Rod Packing Replacement

★ Step 3: Assess cost of replacements

◆ Packing ring replacement costs depend on the number of cylinders and the type of ring
  ▪ Cost of a set of rings: $500 to $800
    (with cups and case) $1500 to $2500

◆ Rod replacement costs vary with rod dimension and rod type
  ▪ Cost of Piston Rod: $1800 to $3500

◆ Installation costs roughly equal equipment costs
Step 4: Determine economic replacement threshold

- Economic replacement threshold defines the specific point at which it is cost effective to replace rings and rods.

- Discounted cash flow method
  - Economic replacement threshold (cfh)
    \[ \text{cfh} = \frac{\text{CR} \times \text{DF} \times 1,000}{\text{H} \times \text{GP}} \]
  - where, \( \text{CR} \) = cost of replacement ($)
    \( \text{H} \) = hours of compressor operation per year
    \( \text{GP} \) = gas price ($/Mcf)
    \( \text{DF} \) = discount factor = \[ \frac{i \times (1+i)^n}{(1+i)^n - 1} \]
    \( i \) = discount rate or company hurdle rate
    \( n \) = payback period selected
Is Recovery Profitable?

✿ Step 5: Replace packing and rods when cost effective

◆ Example:

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<tr>
<th></th>
<th>Rings Only</th>
<th>Rod and Rings</th>
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</thead>
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<tr>
<td>Rings:</td>
<td>$1,200</td>
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</tr>
<tr>
<td>Rod:</td>
<td>$0</td>
<td>Rod:</td>
</tr>
<tr>
<td>Gas:</td>
<td>$3/Mcf</td>
<td>Gas:</td>
</tr>
<tr>
<td>Operating:</td>
<td>8,500 hrs/yr</td>
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<tr>
<td>Leak Reduction</td>
<td>Payback Period</td>
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<tr>
<td>(cfh)</td>
<td>(years)</td>
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</tbody>
</table>

Based on 10% interest rate
Mcf = thousand cubic feet, cfh = cubic feet per hour
Industry Experience on New Rod Packing Material and Coatings

☆ New packing materials can improve the life and performance of equipment

◆ Carbon impregnated Teflon® rings cost almost the same as bronze rings but last about one year longer
  ▪ Other factors like proper installation, cooling and lubrication play an important role
◆ Piston rods coated with tungsten carbide or chromium increase service life of rods
◆ Axially loaded packing installed in one of the last two cups reduces emissions
Axially Loaded Three Ring Rod Packing

Source: Compressor Engineering Corporation
Discussion Questions

★ What is your practice on replaced rod packing in reciprocating compressors?
★ How can the Lessons Learned study 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?