Methane Savings from Compressors and VRUs

Innovative Technologies for the Oil & Gas Industry: Product Capture, Process Optimization, and Pollution Prevention

Targa Resources and the Gas Processors Association

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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?
- Methane Losses from Centrifugal Compressors
- Methane Savings through Dry Seals
- Is Wet Seal Replacement Profitable?
- Vapor Recovery Units (VRUs)
- Discussion

- Reciprocating Compressors: 17 Bcf
- Centrifugal Compressors: 5 Bcf
- Gas Engine Exhaust: 7 Bcf
- Blowdowns: 2 Bcf
- Plant Fugitives: 2 Bcf
- Dehydrators and Pumps: 1 Bcf
- Other Sources: 1 Bcf

Note: Storage Tank Venting from Production = 7 Bcf
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
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
# Methane Losses from Rod Packing

<table>
<thead>
<tr>
<th>Emission from Running Compressor</th>
<th>99 cf/hour-packing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission from Idle/Pressurized Compressor</td>
<td>145 cf/hour-packing</td>
</tr>
<tr>
<td>Leakage from Packing Cup</td>
<td>79 cf/hour-packing</td>
</tr>
<tr>
<td>Leakage from Distance Piece</td>
<td>34 cf/hour-packing</td>
</tr>
</tbody>
</table>

## Leakage from Rod Packing on Running Compressors

<table>
<thead>
<tr>
<th>Packing Type</th>
<th>Bronze</th>
<th>Bronze/Steel</th>
<th>Bronze/Teflon</th>
<th>Teflon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak Rate (cf/hour)</td>
<td>70</td>
<td>63</td>
<td>150</td>
<td>24</td>
</tr>
</tbody>
</table>

## Leakage from Rod Packing on Idle/Pressurized Compressors

<table>
<thead>
<tr>
<th>Packing Type</th>
<th>Bronze</th>
<th>Bronze/Steel</th>
<th>Bronze/Teflon</th>
<th>Teflon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak Rate (cf/hour)</td>
<td>70</td>
<td>N/A</td>
<td>147</td>
<td>22</td>
</tr>
</tbody>
</table>

Source: Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations – PRCI/ GRI/ EPA
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

Economic Replacement Threshold (scfh) = \( \frac{CR \cdot DF \cdot 1000}{(H \cdot GP)} \)

Where:

- CR = Cost of replacement ($)
- DF = Discount factor (%) at interest \( i \)
- H = Hours of compressor operation per year
- GP = Gas price ($/Mcf)

\[ DF = \frac{i(1+i)^n}{(1+i)^n - 1} \]
Is Rod Packing Replacement Profitable?

Periodically measure leakage increase

<table>
<thead>
<tr>
<th>Rings Only</th>
<th>Rod and Rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rings: $1,200</td>
<td>Rings: $1,200</td>
</tr>
<tr>
<td>Rod: $0</td>
<td>Rod: $7,000</td>
</tr>
<tr>
<td>Gas: $7/Mcf</td>
<td>Gas: $7/Mcf</td>
</tr>
<tr>
<td>Operating: 8,000 hrs/yr</td>
<td>Operating: 8,000 hrs/yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leak Reduction Expected (scfh)</th>
<th>Payback (yr)</th>
<th>Leak Reduction Expected (scfh)</th>
<th>Payback (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.4</td>
<td>1</td>
<td>146.4</td>
<td>1</td>
</tr>
<tr>
<td>10.7</td>
<td>2</td>
<td>73.2</td>
<td>2</td>
</tr>
<tr>
<td>7.1</td>
<td>3</td>
<td>48.8</td>
<td>3</td>
</tr>
<tr>
<td>5.4</td>
<td>4</td>
<td>36.6</td>
<td>4</td>
</tr>
</tbody>
</table>

Based on 10% interest rate
Mcf = thousand cubic feet, scfh = standard cubic feet per hour
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)
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
Natural 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.
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 $112,000 to $651,000 at $7/Mcf
## Economics of Replacing Seals

Compare costs and savings for a 6-inch shaft beam compressor

### Cost Category

<table>
<thead>
<tr>
<th></th>
<th>Dry Seal ($)</th>
<th>Wet Seal ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Implementation Costs</strong>¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal costs (2 dry @ $10,000/shaft-inch, w/testing)</td>
<td>$120,000</td>
<td></td>
</tr>
<tr>
<td>Seal costs (2 wet @ $5,000/shaft-inch)</td>
<td></td>
<td>$60,000</td>
</tr>
<tr>
<td>Other costs (engineering, equipment installation)</td>
<td>$120,000</td>
<td>$0</td>
</tr>
<tr>
<td><strong>Total Implementation Costs</strong></td>
<td>$240,000</td>
<td>$60,000</td>
</tr>
<tr>
<td><strong>Annual O&amp;M</strong></td>
<td>$10,000</td>
<td>$73,000</td>
</tr>
<tr>
<td><strong>Annual Methane Emissions</strong> (@ $7/Mcf; 8,000 hr/yr)</td>
<td>$20,160</td>
<td>$336,000</td>
</tr>
<tr>
<td>2 dry seals at a total of 6 scfm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 wet seals at a total of 100 scfm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Costs Over 5-Year Period</strong></td>
<td>$390,800</td>
<td>$2,105,000</td>
</tr>
<tr>
<td><strong>Total Dry Seal Savings Over 5 Years</strong></td>
<td>$1,714,000</td>
<td></td>
</tr>
<tr>
<td>Savings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methane Emissions Reductions (Mcf; at 45,120 Mcf/yr)</td>
<td>225,600</td>
<td></td>
</tr>
</tbody>
</table>

¹ Flowserve Corporation
Is Wet Seal Replacement Profitable?

- Replacing wet seals in a 6 inch shaft beam compressor operating 8,000 hr/yr
  - Net Present Value = $1,216,100
    - Assuming a 10% discount over 5 years
  - Internal Rate of Return = 171%
  - Payback Period = 7 months
    - Ranges from 4 to 15 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
The Heart of a VRU is the Compressor

- Reciprocating and Centrifugal compressors are best in dry gas service – NOT vapor recovery
  - Vapor recovered from storage tanks will be “wet” gas (at the liquid saturation point)
  - Wet gas fouls the valves & seals/ compromises lube oil
- VRU installations commonly use compressors that work well with wet gas
Options for Vapor Recovery Units

- **Recommended choices**
  - Rotary compressors – require electrical power or engine driver
  - Sliding Vane or Rotary Screw Compressors
  - Scroll compressors

- **Alternative, niche technologies**
  - EVRU™ – replaces rotary compressor and contains no moving parts
  - Vapor Jet system - requires high pressure water motive

- **Choices not recommended**
  - Reciprocating compressors
  - Centrifugal compressors
Vapor Recovery - Sources of Methane Losses

Flash losses
- Occur when crude is transferred from a gas-oil separator at higher pressure to a storage tank at atmospheric pressure

Working losses
- Occur when crude levels change and when crude in tank is agitated

Standing losses
- Occur with daily and seasonal temperature and barometric pressure changes
Estimated Volume of Tank Vapors

- Vapor Vented from Tanks, cubic foot / barrel
- Gas/Oil Ratio

Pressure of Vessel Dumping to Tank (Psig)

1. **Under 30° API**
2. **30° API to 39° API**
3. **40° API and Over**

°API = API gravity

API Gravities

10 20 30 40 50 60 70 80
Is It REALLY that much gas?

Video Clip
Vapor Recovery Installations
Vapor Recovery Installations
Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps

- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system

- Tank batteries not subject to air regulations
What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated
Is Recovery Profitable?

<table>
<thead>
<tr>
<th>Peak Capacity (Mcf / day)</th>
<th>Installation &amp; Capital Costs¹ ($ / year)</th>
<th>O &amp; M Costs ($ / year)</th>
<th>Value of Gas² ($ / year)</th>
<th>Annual Savings</th>
<th>Simple Payback (months)</th>
<th>Return on Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>26,470</td>
<td>5,250</td>
<td>$ 51,465</td>
<td>$ 46,215</td>
<td>7</td>
<td>175%</td>
</tr>
<tr>
<td>50</td>
<td>34,125</td>
<td>6,000</td>
<td>$ 102,930</td>
<td>$ 96,930</td>
<td>5</td>
<td>284%</td>
</tr>
<tr>
<td>100</td>
<td>41,125</td>
<td>7,200</td>
<td>$ 205,860</td>
<td>$ 198,660</td>
<td>3</td>
<td>483%</td>
</tr>
<tr>
<td>200</td>
<td>55,125</td>
<td>8,400</td>
<td>$ 411,720</td>
<td>$ 403,320</td>
<td>2</td>
<td>732%</td>
</tr>
<tr>
<td>500</td>
<td>77,000</td>
<td>12,000</td>
<td>$ 1,029,300</td>
<td>$ 1,017,300</td>
<td>1</td>
<td>1321%</td>
</tr>
</tbody>
</table>

¹ Unit Cost plus estimated installation at 75% of unit cost
² $11.28 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)
Discussion

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