Natural Gas Dehydration

Lessons Learned from Natural Gas STAR

Producers and Processors Technology Transfer Workshop
ConocoPhillips and EPA’s Natural Gas STAR Program
Kenai, AK
May 25, 2006

Natural Gas Dehydration: Agenda

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

- Dehydrators and pumps account for:
  - 18 Bcf of methane emissions in the production, gathering, and boosting sector
  - 1 Bcf of methane emissions in the processing sector

![Pie chart showing methane losses from various sources](chart.png)

What is the Problem?

- Produced gas is saturated with water, which must be removed for gas processing and transmission
- Glycol dehydrators are the most common equipment to remove water from gas
  - 36,000 dehydration systems in natural gas production, gathering, and boosting
  - Most use triethylene glycol (TEG)
- Glycol dehydrators create emissions
  - Methane, VOCs, HAPs from reboiler vent
  - Methane from pneumatic controllers

Source: [www.prideofthehill.com](http://www.prideofthehill.com)
Basic Glycol Dehydrator System Process Diagram

Methane Recovery: Five Options
- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Zero emission dehydrator
- Replace glycol unit with desiccant dehydrator
- Flare (no recovery)
Optimizing Glycol Circulation Rate

- Gas well’s initial production rate decreases over its lifespan
  - Glycol circulation rates designed for initial, highest production rate
  - Operators tend to “set it and forget it”
- Glycol overcirculation results in more methane emissions and fuel gas consumption without significant reduction in gas moisture content
  - Partners found circulation rates two to three times higher than necessary
  - Methane emissions and fuel gas consumption are directly proportional to circulation rate

Installing Flash Tank Separator (FTS)

- Flashed methane can be captured using an FTS
- Many units are not using an FTS

![Bar chart showing comparison between With FTS and Without FTS](source: API)
Methane Recovery

- Recovers ~ 90% of methane emissions
- Reduces VOCs by 10 to 90%
- Must have an outlet for low pressure gas
  - Fuel
  - Compressor suction
  - Vapor recovery unit

Flash Tank Costs

- Lessons Learned study provides guidelines for scoping costs, savings and economics
- Capital and installation costs:
  - Capital costs range from $5,000 to $10,000 per flash tank
  - Installation costs range from $2,400 to $4,300 per flash tank
- Negligible O&M costs
Installing Electric Pump

Overall Benefits

- Financial return on investment through gas savings
- Increased operational efficiency
- Reduced O&M costs
- Reduced compliance costs (HAPs, BTEX)
- Similar footprint as gas assist pump
- Limitation: must have electric power source
Is Recovery Profitable?

Three Options for Minimizing Glycol Dehydrator Emissions

<table>
<thead>
<tr>
<th>Option</th>
<th>Capital Costs</th>
<th>Annual O&amp;M Costs</th>
<th>Emissions Savings</th>
<th>Payback Period¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize Circulation Rate</td>
<td>Negligible</td>
<td>Negligible</td>
<td>130 – 13,133 Mcf/year</td>
<td>Immediate</td>
</tr>
<tr>
<td>Install Flash Tank</td>
<td>$5,000 - $10,000</td>
<td>Negligible</td>
<td>236 – 7,098 Mcf/year</td>
<td>2 months – 6 years</td>
</tr>
<tr>
<td>Install Electric Pump</td>
<td>$4,200 - $23,400</td>
<td>$3,600</td>
<td>360 – 36,000 Mcf/year</td>
<td>&lt; 1 month – several years</td>
</tr>
</tbody>
</table>

¹ – Gas price of $7/Mcf

Zero Emission Dehydrator

- Combines many emission saving technologies into one unit
- Still gas is vaporized from the rich glycol when it passes through the glycol reboiler
- Condenses the still gas and separates the skimmer gas from the condensate using an eductor
- Skimmer gas is rerouted back to reboiler for use as fuel
Overall Benefits

- Still gas is condensable (heavier hydrocarbons and water) and can be removed from the non-condensable components using a still condenser.
- The condensed liquid will be a mixture of water and hydrocarbons and can be further separated.
- Hydrocarbons (mostly methane) are valuable and can be recovered as fuel or product.
- By collecting the still column vent gas emissions are greatly reduced.

Replace Glycol Unit with Desiccant Dehydrator

- Desiccant Dehydrator
  - Wet gasses pass through drying bed of desiccant tablets
  - Tablets absorb moisture from gas and dissolve
- Moisture removal depends on:
  - Type of desiccant (salt)
  - Gas temperature and pressure

<table>
<thead>
<tr>
<th>Hygroscopic Salts</th>
<th>Typical T and P for Pipeline Spec</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium chloride</td>
<td>47°F 440 psig</td>
<td>Least expensive</td>
</tr>
<tr>
<td>Lithium chloride</td>
<td>60°F 250 psig</td>
<td>More expensive</td>
</tr>
</tbody>
</table>
Savings

- Gas savings
  - Gas vented from glycol dehydrator
  - Gas vented from pneumatic controllers
  - Gas burner for fuel in glycol reboiler
  - Gas burner for fuel in gas heater
- Less gas vented from desiccant dehydrator
- Methane emission savings calculation
  - Glycol vent + Pneumatics vents – Desiccant vents
- Operation and maintenance savings
  - Glycol O&M + Glycol fuel – Desiccant O&M

Desiccant Dehydrator and Glycol Dehydrator Cost Comparison

<table>
<thead>
<tr>
<th>Type of Costs and Savings</th>
<th>Desiccant ($/yr)</th>
<th>Glycol ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desiccant (includes the initial fill)</td>
<td>13,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Glycol</td>
<td>9,750</td>
<td>15,000</td>
</tr>
<tr>
<td>Other costs (installation and engineering)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Implementation Costs</td>
<td>22,750</td>
<td>35,000</td>
</tr>
<tr>
<td>Annual Operating and Maintenance Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desiccant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of desiccant refill ($1.20/pound)</td>
<td>2,059</td>
<td></td>
</tr>
<tr>
<td>Cost of brine disposal</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Labor cost</td>
<td>1,560</td>
<td></td>
</tr>
<tr>
<td>Glycol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of glycol refill ($4.50/gallon)</td>
<td></td>
<td>167</td>
</tr>
<tr>
<td>Material and labor cost</td>
<td></td>
<td>4,680</td>
</tr>
<tr>
<td>Total Annual Operation and Maintenance Costs</td>
<td>3,633</td>
<td>4,847</td>
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</table>

Based on 1 MMcfd natural gas operating at 450 psig and 47°F
Installation costs assumed at 75% of the equipment cost
Desiccant Dehydrator Economics

NPV = $18,236  IRR = 62%  Payback = 18 months

<table>
<thead>
<tr>
<th>Type of Costs and Savings</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
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<tbody>
<tr>
<td>Capital costs</td>
<td>-$22,750</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Avoided O&amp;M costs</td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
<td></td>
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<tr>
<td>Value of gas saved 1</td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
<td></td>
</tr>
<tr>
<td>Glycol dehy. salvage value 2</td>
<td>$10,000</td>
<td>$8,655</td>
<td>$8,655</td>
<td>$8,655</td>
<td>$8,655</td>
<td></td>
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<tr>
<td>Total</td>
<td>-$12,750</td>
<td>$8,655</td>
<td>$8,655</td>
<td>$8,655</td>
<td>$8,655</td>
<td></td>
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</table>

1 – Gas price = $7/Mcf. Based on 563 Mcf/yr of gas venting savings and 500 Mcf/yr of fuel gas savings
2 – Salvage value estimated as 50% of glycol dehydrator capital cost

Partner Experience

One partner routes glycol gas from FTS to fuel gas system, saving 24 Mcf/day (8,760 Mcf/year) at each dehydrator unit

Texaco has installed FTS

- Recovered 98% of methane from the glycol
- Reduced emissions from 1,232 - 1,706 Mcf/year to <47 Mcf/year
Lessons Learned

- Optimizing glycol circulation rates increase gas savings, reduce emissions
  - Negligible cost and effort
- Electric pumps reduce O&M costs, reduce emissions, increase efficiency
  - Require electrical power source
- Zero emission dehydrator can virtually eliminate emissions
  - Requires electrical power source
- Desiccant dehydrator reduce O&M costs and reduce emissions compared to glycol
  - Best for cold gas
- FTS reduces methane emissions by ~ 90 percent
  - Require a low pressure gas outlet, one option is a VRU

Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use rotary compressor to suck vapors out of atmospheric pressure storage tanks
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU™ requires source of high pressure gas and intermediate pressure system
  - Vapor Jet requires high pressure water motive
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  - Vapor Jet requires high pressure water motive

Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)
Venturi Jet Ejector*

- High-Pressure Motive Gas (~850 psig)
- Flow Safety Valve
- Low-Pressure Vent Gas from Tanks (0.10 to 0.30 psig)
- Discharge Gas (~40 psia)
- Pressure Indicator
- Temperature Indicator
- Suction Pressure (-0.05 to 0 psig)

*EVRU™ Patented by COMM Engineering
Adapted from SRI/USEPA-GHG-VR-19
psig = pound per square inch, gauge
psia = pounds per square inch, atmospheric

Vapor Jet System*

*Dotted line indicates vapor phase.

*Patented by Hy-Bon Engineering
Vapor Jet System*

- Utilizes produced water in closed loop system to effect gas gathering from tanks
- Small centrifugal pump forces water into Venturi jet, creating vacuum effect
- Limited to gas volumes of 77 Mcf / day and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering

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
Vapor Recovery Installations

Vapor Recovery Installations
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 ($ / year)</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>$1,025,300</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 Questions

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