Natural Gas Dehydration

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

Targa Resources and the Gas Processors Association

July 27, 2006

epa.gov/gasstar
Natural Gas Dehydration: Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion
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

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2004
What is the Problem?

- Produced gas is saturated with water, which must be removed for gas 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
Basic Glycol Dehydrator System Process Diagram

- Inlet Wet Gas
- Dry Sales Gas
- Gas Bypass
- Lean TEG
- Rich TEG
- Fuel Gas
- Water/Methane/VOCs/HAPs To Atmosphere
Methane Recovery: Five Options

- Optimized glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Replace glycol unit with desiccant dehydrator
- Zero emission dehydrator
Optimizing Glycol Circulation Rate

- Gas pressure and flow at gathering/booster stations vary over time
  - Glycol circulation rates are often set at a maximum circulation rate
- Glycol overcirculation results in more methane emissions without significant reduction in gas moisture content
  - Partners found circulation rates two to three times higher than necessary
  - Methane emissions are directly proportional to circulation
- Lessons Learned study: optimize circulation rates
Installing Flash Tank Separator

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

![Bar graph showing MMcfd processed with 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

Low Capital Cost/Quick Payback
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

- Inlet Wet Gas
- Dry Sales Gas
- Electric Motor Driven Pump
- Rich TEG
- Lean TEG
- Pump
- Glycol Contactor
- Water/Methane/VOCs/HAPs To Atmosphere
- Fuel Gas
- Glycol Reboiler/Regenerator
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
## 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
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>
Desiccant Performance

Desiccant Performance Curves at Maximum Pipeline Moisture Spec (7 pounds water / MMcf)
Desiccant Dehydrator Schematic
Estimate Capital Costs

- Determine amount of desiccant needed to remove water
- Determine inside diameter of vessel

Costs for single vessel desiccant dehydrator

- Capital cost varies between $3,000 and $17,000
- Gas flow rates from 1 to 20 MMcf/day
  - Capital cost for 20-inch vessel with 1 MMcf/day gas flow is $6,500
  - Installation cost assumed to be 75% of capital cost

Note:
MMcf = Million Cubic Feet
How Much Desiccant Is Needed?

**Example:**

\[
\begin{align*}
D &= \ ? \\
F &= 1 \text{ MMcf/day} \\
I &= 21 \text{ pounds/MMcf} \\
O &= 7 \text{ pounds/MMcf} \\
B &= 1/3
\end{align*}
\]

**Where:**

\[
\begin{align*}
D &= \text{Amount of desiccant needed (pounds/day)} \\
F &= \text{Gas flow rate (MMcf/day)} \\
I &= \text{Inlet water content (pounds/MMcf)} \\
O &= \text{Outlet water content (pounds/MMcf)} \\
B &= \text{Desiccant/water ratio vendor rule of thumb}
\end{align*}
\]

**Calculate:**

\[
D = F \cdot (I - O) \cdot B \\
D = 1 \cdot (21 - 7) \cdot 1/3 \\
D = 4.7 \text{ pounds desiccant/day}
\]

**Note:**

MMcf = Million Cubic Feet

Source: Van Air
Calculate Vessel Inside Diameter

**Example:**

| ID = ? | ID = Inside diameter of the vessel (inch) |
| D = 4.7 pounds/day | D = Amount of desiccant needed (pounds/day) |
| T = 7 days | T = Assumed refilling frequency (days) |
| B = 55 pounds/cf | B = Desiccant density (pounds/cf) |
| H = 5 inch | H = Height between minimum and maximum bed level (inch) |

**Calculate:**

\[
\text{ID} = 12 \times \sqrt[3]{\frac{4 \times D \times T \times 12}{H \times B \times \pi}} = 16.2 \text{ inch}
\]

Commercially ID available = 20 inch

**Note:**

cf = Cubic Feet
Operating Costs

- Desiccant: $2,059/year for 1 MMcf/day example
  - $1.20/pound desiccant cost
- Brine Disposal: Negligible
  - $1/bbl brine or $14/year
- Labor: $1,560/year for 1 MMcf/day example
  - $30/hour

Total: ~$3,633/year
Savings

Gas savings
- Gas vented from glycol dehydrator
- Gas vented from pneumatic controllers
- Gas burned for fuel in glycol reboiler
- Gas burned 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
Gas Vented from Glycol Dehydrator

Example:
- GV = ?
- F = 1 MMcf/day
- W = 21-7 pounds H₂O/MMcf
- R = 3 gallons/pound
- OC = 150%
- G = 3 cf/gallon

Where:
- GV = Gas vented annually (Mcf/year)
- F = Gas flow rate (MMcf/day)
- W = Inlet-outlet H₂O content (pounds/MMcf)
- R = Glycol/water ratio (rule of thumb)
- OC = Percent over-circulation
- G = Methane entrainment (rule of thumb)

Calculate:

\[ GV = \frac{F \times W \times R \times OC \times G \times 365 \text{ days/year}}{1,000 \text{ cf/Mcf}} \]

\[ GV = 69 \text{ Mcf/year} \]
Gas Vented from Pneumatic Controllers

Example:
GE = ?
PD = 4
EF = 126 Mcf/device/year

Calculate:
GE = EF * PD
GE = 504 Mcf/year

Where:
GE = Annual gas emissions (Mcf/year)
PD = Number of pneumatic devices per dehydrator
EF = Emission factor (Mcf natural gas leakage/pneumatic devices per year)

Source: norriseal.com
Gas Lost from Desiccant Dehydrator

Example:
GLD = ?
ID = 20 inch (1.7 feet)
H = 76.75 inch (6.4 feet)
%G = 45%
P₁ = 15 Psia
P₂ = 450 Psig
T = 7 days

Where:
GLD = Desiccant dehydrator gas loss (Mcf/year)
ID = Inside Diameter (feet)
H = Vessel height by vendor specification (feet)
%G = Percentage of gas volume in the vessel
P₁ = Atmospheric pressure (Psia)
P₂ = Gas pressure (Psig)
T = Time between refilling (days)

Calculate:
GLD = \( \frac{H \times ID^2 \times \pi \times P_2 \times %G \times 365 \text{ days/year}}{4 \times P_1 \times T \times 1,000 \text{ cf/Mcf}} \)
GLD = 10 Mcf/year

Desiccant Dehydrator Unit
Source: usedcompressors.com
## Desiccant Dehydrator and Glycol Dehydrator Cost Comparison

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

<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>167</td>
<td></td>
</tr>
<tr>
<td>Material and labor cost</td>
<td>4,680</td>
<td></td>
</tr>
<tr>
<td>Total Annual Operation and Maintenance Costs:</td>
<td>3,633</td>
<td>4,847</td>
</tr>
</tbody>
</table>
## 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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</thead>
<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></td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
<td>$4,847</td>
</tr>
<tr>
<td>Value of gas saved(^1)</td>
<td></td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
<td>$7,441</td>
</tr>
<tr>
<td>Glycol dehy. salvage value(^2)</td>
<td>$10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>$8,655</td>
</tr>
</tbody>
</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
  - Recovers 98% of methane from the glycol
  - Reduced emissions from 1,232 - 1,706 Mcf/year to <47 Mcf/year
Zero Emission Dehydrator

- Combines many emission saving technologies into one unit
- 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
- Still gas is vaporized from the rich glycol when it passes through the glycol reboiler
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 to be sold as a product.

- By collecting the still column vent gas emissions are greatly reduced.
Lessons Learned

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

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits