Natural Gas Dehydration

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

Devon Energy and EPA’s Natural Gas STAR Program
Fort Worth, TX
June 6, 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

Pneumatic Devices 60 Bcf

Dehydrators and Pumps 18 Bcf

Storage Tank Venting 7 Bcf

Other Sources 14 Bcf

Meters and Pipeline Leaks 9 Bcf

Well Venting and Flaring 9 Bcf

Gas Engine Exhaust 12 Bcf

Offshore Operations 30 Bcf

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 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
Basic Glycol Dehydrator System Process Diagram

Glycol Contactor

Dry Sales Gas

Inlet Wet Gas

Glycol Energy Exchange Pump

Driver

Rich TEG

Lean TEG

Glycol Reboiler/Regenerator

Fuel Gas

Water/Methane/VOCs/HAPs To Atmosphere

Gas Bypass

Gas Bypass

Dry Sales Gas

Inlet Wet Gas

Lean TEG

Rich TEG

Glycol Reboiler/Regenerator

Fuel Gas

Water/Methane/VOCs/HAPs To Atmosphere
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

![Graph showing percent of 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** to **Glycol Contactor**
- **Dry Sales Gas** from **Glycol Contactor**
- **Electric Motor Driven Pump**
- **Rich TEG** from **Electric Motor Driven Pump**
- **Lean TEG** to **Pump**
- **Fuel Gas**
- **Water/Methane/VOCs/HAPs** to **Atmosphere**
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 Period²</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>
Desiccant Performance

Desiccant Performance Curves at Maximum Pipeline Moisture Spec (7 pounds water / MMcf)

Max Spec Line for CaCl$_2$

Max Spec Line for LiCl$_2$

Source: Air & Vacuum Process, Inc.
Desiccant Dehydrator Schematic

- Filler Hatch
- Dry Sales Gas
- Inlet Wet Gas
- Drying Bed
- Brine
- Drain Valve
- Support Grid
- Desiccant Tablets
- Maximum Desiccant Level
- Minimum Desiccant Level
Estimate Capital Costs

- Determine amount of desiccant needed to remove water
- Determine 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
- Normally installed in pairs
  - One drying, one refilled for standby

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

Example:

D = ?
F = 1 MMcf/day
I = 21 pounds/MMcf
O = 7 pounds/MMcf
B = 1/3

Calculate:

D = F * (I - O) * B
D = 1 *(21 - 7) * 1/3
D = 4.7 pounds desiccant/day

Where:

D = Amount of desiccant needed (pounds/day)
F = Gas flow rate (MMcf/day)
I = Inlet water content (pounds/MMcf)
O = Outlet water content (pounds/MMcf)
B = Desiccant/water ratio vendor rule of thumb

Note:

MMcf = Million Cubic Feet

Source: Van Air
Calculate Vessel Diameter

Example:
ID = ?
D = 4.7 pounds/day
T = 7 days
B = 55 pounds/cf
H = 5 inch

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

Calculate:
ID = 12* \sqrt{\frac{4*D*T*12}{H*B*\pi}} = 16.2\ inch

Standard ID available = 20\ inch

Note:
cf = Cubic Feet

Source: Van Air
Operating Costs

- 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 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
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

Calculate:
GV = (F * W * R * OC * G * 365 days/year) / 1,000 cf/Mcf

GV = 69 Mcf/year

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)

Glycol Dehydrator Unit
Source: GasTech
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 bleed/pneumatic devices per year)

Source: norriseal.com
Norriseal
Pneumatic Liquid Level Controller
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

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

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)
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>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>

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>
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<td></td>
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<tr>
<td>Avoided O&amp;M costs</td>
<td></td>
<td>$4,847</td>
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<tr>
<td>Value of gas saved&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>$7,441</td>
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<tr>
<td>Glycol dehy. salvage value&lt;sup&gt;2&lt;/sup&gt;</td>
<td>$10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>-$12,750</td>
<td>$8,655</td>
<td>$8,655</td>
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<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
  - 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
- FTS reduces methane emissions by ~ 90 percent
  - Require a low pressure gas outlet
- 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
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?