Natural Gas Dehydration

Lessons Learned from the Natural Gas STAR Program

Source Reduction Training

Interstate Oil and Gas Compact Commission

Charleston, West Virginia
February 27, 2009

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:
- 13 Billion cubic feet (Bcf) of methane emissions in the production, gathering, and boosting sectors

Storage Tank Venting: 6 Bcf
Well Venting and Flaring: 8 Bcf
Meters and Pipeline Leaks: 8 Bcf
Compressor Fugitives, Venting, and Engine Exhaust: 13 Bcf
Dehydrators and Pumps: 13 Bcf
Offshore Operations: 29 Bcf
Pneumatic Devices: 48 Bcf

Source:

Natural Gas STAR reductions from gathering and boosting operations have been moved to the production sector.

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 units in natural gas production, gathering, and boosting
  - Most use triethylene glycol (TEG)
- Glycol dehydrators create emissions
  - Methane, Volatile Organic Compounds (VOCs), Hazardous Air Pollutants (HAPs) from reboiler vent
  - Methane from pneumatic controllers

Source:
www.prideofthehill.com
Basic Glycol Dehydrator System Process Diagram

Methane Recovery
- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Re-route glycol skimmer gas
- Replace glycol unit with desiccant dehydrator
- Other opportunities
Optimizing Glycol Circulation Rate

- Gas pressure and flow at wellhead dehydrators generally declines 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 (FTS)

- Methane that flashes from rich glycol in an energy-exchange pump can be captured using an FTS
- Many small units are not using an FTS
Methane Recovery

- Recovers about 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 $3,375 to $6,751 per flash tank
  - Installation costs range from $1,200 to $2,160 per flash tank
- Negligible Operational & Maintenance (O&M) costs
Is Recovery Profitable?

Two 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>394 to 39,420 Mcf/year</td>
<td>Immediate</td>
</tr>
<tr>
<td>Install Flash Tank</td>
<td>$6,500 to $18,800</td>
<td>Negligible</td>
<td>710 to 10,643 Mcf/year</td>
<td>4 to 11 months</td>
</tr>
</tbody>
</table>

¹ – Gas price of $7/Mcf

Re-route Glycol Skimmer Gas

- Non-condensable skimmer gas from the condensate separators in glycol dehydrators can be re-routed to:
  - Reboiler for fuel use
  - Low pressure fuel systems for fuel use

- The condensate separator must operate at a higher pressure than the destination for skimmer gas combustion
Skimmer Gas Re-routing Costs

- Capital and installation costs:
  - Capital costs are below $1,000
  - Installation costs range from $100 to $1,000
  - Payback in less than a year

- Negligible Operational & Maintenance (O&M) costs

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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>&lt;47°F @ 440 psig</td>
<td>Least expensive</td>
</tr>
<tr>
<td>Lithium chloride</td>
<td>&lt;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 CaCl₂
Max Spec Line for LiCl₂

Desiccant Dehydrator Schematic

Filler Hatch
Maximum Desiccant Level
Dry Sales Gas
Minimum Desiccant Level
Drying Bed
Desiccant Tablets
Inlet Wet Gas
Support Grid
Brine
Drain Valve
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 $3,500 and $22,000
  - Gas flow rates from 1 to 20 MMcf/day
    - Capital cost for 20-inch vessel with 1 MMcf/day gas flow is $8,100
    - Installation cost assumed to be 75% of capital cost
- Normally installed in pairs
  - One drying, one refilled for standby

How Much Desiccant Is Needed?

Example:

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

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

Calculate:

\[ D = F \times (I - O) \times B \]
\[ D = 1 \times (21 - 7) \times \frac{1}{3} \]

D = 4.7 pounds desiccant/day

Source: Van Air
Calculate Vessel Diameter

Example:

\[
\text{ID} = \text{?} \\
D = 4.7 \text{ pounds/day} \\
T = 7 \text{ days} \\
B = 55 \text{ pounds/cf} \\
H = 5 \text{ inch}
\]

Where:

\[
\text{ID} = \text{Internal diameter of the vessel (inch)} \\
D = \text{Amount of desiccant needed (pounds/day)} \\
T = \text{Assumed refilling frequency (days)} \\
B = \text{Desiccant density (pounds/cf)} \\
H = \text{Height between minimum and maximum bed level (inch)}
\]

Calculate:

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

Standard ID available = \[20 \text{ inch}\]

cf = cubic feet

Source: Van Air

Operating Costs

- Operating costs
  - Desiccant: $2,556/year for 1 MMcf/day example
    - $1.50/pound desiccant cost
  - Brine Disposal: Negligible
    - $1/bbl brine or $14/year
  - Labor: $2,080/year for 1 MMcf/day example
    - $40/hour
- Total: about $4,650/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 & Heater fuel – Desiccant O&M

Gas Vented from Glycol Dehydrator

**Example:**

Where:
- \( GV = \) Gas vented annually (Mcf/year)
- \( F = \) Gas flow rate (MMcf/day)
- \( W = \) 21-7 pounds H\(_2\)O/MMcf
- \( R = \) 3 gallons/pound
- \( OC = \) 150%
- \( G = \) 3 cf/gallon

**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 bleed/pneumatic devices per year)

Source: norriseal.com

Gas Burned as Fuel for Glycol Dehydrator

Gas fuel for glycol reboiler
- 1 MMcf/day dehydrator
- Removing 14 lb water/MMcf
- Reboiler heat rate: 1,124 Btu/gal TEG
- Heat content of natural gas: 1,027 Btu/scf

Fuel requirement: 17 Mcf/year

Gas fuel for gas heater
- 1 MMcf/day dehydrator
- Heat gas from 47°F to 90°F
- Specific heat of natural gas: 0.441 Btu/lb-°F
- Density of natural gas: 0.0502 lb/cf
- Efficiency: 70%

Fuel requirement: 483 Mcf/year
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 = Internal 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:**

\[
GLD = H \times ID^2 \times \pi \times P₂ \times \%G \times 365 \text{ days/year} \div 4 \times P₁ \times T \times 1,000 \text{ cf/Mcf}
\]

GLD = 10 Mcf/year

Natural Gas Savings

- Gas vented from glycol dehydrator: 69 Mcf/year
- Gas vented from pneumatic controls: +504 Mcf/year
- Gas burned in glycol reboiler: +17 Mcf/year
- Gas burned in gas heater: +483 Mcf/year
- Minus desiccant dehydrator vent: -10 Mcf/year

Total savings: 1,063 Mcf/year

Value of gas savings (@ $7/Mcf): $7,441/year
## 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>16,097</td>
<td>24,764</td>
</tr>
<tr>
<td>Glycol</td>
<td>12,073</td>
<td>18,573</td>
</tr>
<tr>
<td>Other costs (installation and engineering)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Implementation Costs:</td>
<td>28,169</td>
<td>43,337</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 ($1.50/pound)</td>
<td>2,556</td>
<td></td>
</tr>
<tr>
<td>Cost of brine disposal</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Labor cost</td>
<td>2,080</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>206</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>4,650</td>
<td>4,886</td>
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</tbody>
</table>

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

### Desiccant Dehydrator Economics

- **NPV:** $13,315
- **IRR:** 39%
- **Payback:** 25 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>
</tr>
</thead>
<tbody>
<tr>
<td>Capital costs</td>
<td>-$28,169</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Avoided O&amp;M costs</td>
<td>$4,886</td>
<td>$4,886</td>
<td>$4,886</td>
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<td></td>
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<tr>
<td>O&amp;M costs - Desiccant</td>
<td>-$4,650</td>
<td>-$4,650</td>
<td>-$4,650</td>
<td>-$4,650</td>
<td>-$4,650</td>
<td></td>
</tr>
<tr>
<td>Value of gas saved 1</td>
<td>$7,441</td>
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<tr>
<td>Glycol dehy. salvage value 2</td>
<td>$12,382</td>
<td>$7,677</td>
<td>$7,677</td>
<td>$7,667</td>
<td>$7,667</td>
<td>$7,667</td>
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<tr>
<td>Total</td>
<td>-$15,787</td>
<td>$7,677</td>
<td>$7,677</td>
<td>$7,667</td>
<td>$7,667</td>
<td>$7,667</td>
</tr>
</tbody>
</table>

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

- Optimize glycol circulation rates
- Since 2000, Natural Gas STAR Partners have optimized and reduced glycol circulation rates, achieving:
  - Over 200 MMcf in emissions reductions
  - Over $0.6 million in savings

Other Partner Reported Opportunities

- Flare regenerator off-gas (no economics)
- With a vent condenser,
  - Route skimmer gas to firebox
  - Route skimmer gas to tank with VRU
- Instrument air for controllers and glycol pump
- Mechanical control valves
- Pipe gas pneumatic vents to tank with VRU (not reported yet)
Lessons Learned

- Optimizing glycol circulation rates increase gas savings, reduce emissions
  - Negligible cost and effort
- FTS reduces methane emissions by about 90 percent
  - Require a low pressure gas outlet
- Re-routing glycol skimmer gas to fuel gas or reboiler reduces emissions and increases efficiency
- Desiccant dehydrator reduce O&M costs and reduce emissions compared to glycol
- Miscellaneous other Partner Related Opportunities can have big savings

Discussion

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