Natural Gas Dehydration

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

Devon Energy and EPA’s Natural Gas STAR Program

Casper, Wyoming

August 30, 2005
Natural Gas Dehydration: Agenda

★ Methane Losses
★ Methane Recovery
★ Is Recovery Profitable?
★ Industry Experience
★ Discussion Questions
Methane Losses from Production

1990-2004 Partners reported saving ~ 12.5 Bcf (Billion cubic feet) from dehydrators

- Storage Tank Venting: 9 Bcf
- Meters and Pipeline Leaks: 10 Bcf
- Gas Engine Exhaust: 12 Bcf
- Dehydrators and Pumps: 17 Bcf
- Well Venting and Flaring: 18 Bcf
- Other Sources: 21 Bcf
- Pneumatic Devices: 61 Bcf

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
  ◆ 38,000 dehydration systems in the natural gas production sector
  ◆ 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

Glycol Contactor

Dry Sales Gas

Glycol Energy Exchange Pump

Lean TEG

Rich TEG

Glycol Reboiler/Regenerator

Fuel Gas

Water/Methane/VOCs/HAPs To Atmosphere

Reducing Emissions, Increasing Efficiency, Maximizing Profits
Methane Recovery: Four Options

- Optimized glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Replace glycol unit with desiccant dehydrator
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 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 rate
Installing Flash Tank Separator

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

- Recovers ~ 90% of methane emissions
- Reduces VOCs by 10 to 90%
- Must have an outlet for low pressure gas

Reduced Emissions

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

- **Glycol Contactor**
  - **Dry Sales Gas**
  - **Inlet Wet Gas**
  - **Driver**
  - **Lean TEG**
  - **Rich TEG**
  - **Electric Motor Driven Pump**
  - **Pump**

- **Glycol Reboiler/Regenerator**
  - **Water/Methane/VOCs/HAPs To Atmosphere**
  - **Fuel Gas**

**Reducing Emissions, Increasing Efficiency, Maximizing Profits**
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 Period</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>5 months – 17 months</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; 2 months – several years</td>
</tr>
</tbody>
</table>
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 Curves at Maximum Pipeline Moisture Spec (7 pounds water / MMcf)

Max Spec Line for CaCl₂

Max Spec Line for LiCl₂

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

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

Reducing Emissions, Increasing Efficiency, Maximizing Profits
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

Reducing Emissions, Increasing Efficiency, Maximizing Profits
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 * (I - O) * B
D = 1 * (21 - 7) * 1/3
D = 4.7 pounds desiccant/day

Note:
MMcf = Million Cubic Feet

Source: Van Air
Calculate Vessel Inside Diameter

Example:

<table>
<thead>
<tr>
<th>Where</th>
<th>ID</th>
<th>D</th>
<th>T</th>
<th>B</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID = 12* $\sqrt{\frac{4<em>D</em>T<em>12}{H</em>B*\pi}}$</td>
<td>?</td>
<td>4.7 pounds/day</td>
<td>7 days</td>
<td>55 pounds/cf</td>
<td>5 inch</td>
</tr>
</tbody>
</table>

Calculate:

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

Commercially ID available = 20 inch

Note:

*cf = Cubic Feet

Source: Van Air

Reducing Emissions, Increasing Efficiency, Maximizing Profits
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 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}

Where:
GV = Gas vented annually (Mcf/year)
F = Gas flow rate (MMcf/day)
W = Inlet-outlet H$_2$O content (pounds/MMcf)
R = Glycol/water ratio (rule of thumb)
OC = Percent over-circulation
G = Methane entrainment (rule of thumb)
Gas Vented from Pneumatic Controllers

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

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

Source: norriseal.com
Norriseal Pneumatic Liquid Level Controller

Reducing Emissions, Increasing Efficiency, Maximizing Profits
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 \cdot ID^2 \cdot \pi \cdot P₂ \cdot %G \cdot 365 \text{ days/year}}{4 \cdot P₁ \cdot T \cdot 1,000 \text{ cf/Mcf}}

GLD = 10 \text{ Mcf/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>13,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Glycol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other costs (installation and engineering)</td>
<td>9,750</td>
<td>15,000</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>167</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
Partner Reported Experience

- Partners report cumulative methane reduction of 12.5 Bcf since 1990
- Past emission reduction estimates for U.S offshore is 500 MMcf/year or $1.5 million/year
Case Study

- 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
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
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?