Natural Gas Dehydration: Agenda

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

- Dehydrators and pumps account for:
  - 15% of methane emissions in the U.S. production, gathering, and boosting sectors (excl. offshore operations)


Natural Gas STAR reductions data shown as published in the inventory.
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
  - 2,000 estimated dehydration units in NG production, gathering, and boosting in Argentina
  - Most use Triethylene Glycol (TEG)
- Glycol dehydrators generate 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 Options

- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Zero emission dehydrator
- 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 over-circulation 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 plus bypass gas can be captured using an FTS
- Many units are not using an FTS

Source: API survey
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

Low Capital Cost/Quick Payback
Flash Tank Costs

- U.S. EPA Lessons Learned study provides guidelines for scoping costs, savings and economics

- Capital and installation costs:
  - Capital costs range from US$3.500 to US$7.000 per flash tank
  - Installation costs range from US$1.200 to US$2.500 per flash tank

- Negligible Operational & Maintenance (O&M) costs
Electric Pump Eliminates Motive Gas

- Inlet Wet Gas
- Motive bypass
- Electric Motor Driven Pump
- Gas Driver
- Rich TEG
- Lean TEG
- Dry Sales Gas
- Water/Methane/VOCs/HAPs To Atmosphere
- Fuel Gas

Glycol Contactor

Glycol Reboiler/Regenerator
Is Recovery Profitable?

- Three options for minimizing glycol dehydrator emissions

<table>
<thead>
<tr>
<th>Option</th>
<th>Capital Costs (US$)</th>
<th>Annual O&amp;M Costs (US$)</th>
<th>Emissions Savings (Mm³/year)</th>
<th>Payback Period¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize Circulation Rate</td>
<td>Negligible</td>
<td>Negligible</td>
<td>11 to 1.116</td>
<td>Immediate</td>
</tr>
<tr>
<td>Install Flash Tank</td>
<td>6.500 to 18.800</td>
<td>Negligible</td>
<td>20 to 301</td>
<td>0.9 to 4.6 years</td>
</tr>
<tr>
<td>Install Electric Pump</td>
<td>1.400 to 13.000</td>
<td>165 to 4.300</td>
<td>10 to 1.019</td>
<td>&lt; 1 year to several years</td>
</tr>
</tbody>
</table>

¹ Gas price of US$70.63/Mm³
Overall Benefits

- Financial return on investment through gas savings
- Increased operational efficiency
- Reduced O&M costs (fuel gas, glycol make-up)
- Reduced hazardous air pollutants (BTEX)
- Electric pump similar footprint as gas assist pump
Zero Emission Dehydrator

- Combines many emission saving technologies into one unit
  - Vapors in the still gas coming off of the glycol reboiler are condensed in a heat exchanger
  - Non-condensable skimmer gas is routed back to the reboiler for fuel use
  - Electric driven glycol circulation pumps used instead of energy-exchange pumps
  - Electric control valves replace gas pneumatics
Overall Benefits: Zero Emissions Dehydrator

- Reboiler vent condenser removes heavier hydrocarbons and water from non-condensables (mainly methane)
- The condensed liquid can be further separated into water and valuable gas liquid hydrocarbons
- Non-condensables (mostly methane) can be recovered as fuel or product
- By collecting the reboiler vent gas, methane (and VOC/HAP) emissions are greatly reduced
- Gas pneumatic control valve vents eliminated
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

### Hygroscopic Salts

<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;8°C @ 30 atm</td>
<td>Least expensive</td>
</tr>
<tr>
<td>Lithium chloride</td>
<td>&lt;16°C @ 17 atm</td>
<td>More expensive</td>
</tr>
</tbody>
</table>
Desiccant Performance

- Desiccant performance at maximum pipeline moisture spec (112 grams water / Mm$^3$)
Desiccant Dehydrator Scheme

- **Inlet Wet Gas**
- **Dry Sales Gas**
- **Filler Hatch**
- **Desiccant Tablets**
- **Support Grid**
- **Drain Valve**
- **Sight glass level indicator**

- **Maximum Desiccant Level**
- **Minimum Desiccant Level**

**Drying Bed**

**Brine**
Desiccant Dehydrator Savings: Gas Vented from Glycol Dehydrator

Example:

\[ GV = ? \]

\[ F = 28,32 \text{ Mm}^3/\text{day} \]

\[ W = 336-112 \text{ gr H}_2\text{O/Mm}^3 \]

\[ R = 0,025 \text{ L/gr} \]

\[ OC = 150\% \]

\[ G = 0,022 \text{ m}^3/\text{L} \]

Calculate:

\[ GV = (F \times W \times R \times OC \times G \times 365 \text{days/year}) \times 1,000 \text{ m}^3/\text{Mm}^3 \]

\[ GV = 1,95 \text{ Mm}^3/\text{year} \]

Where:

\[ GV = \text{Gas vented annually (Mm}^3/\text{year)} \]

\[ F = \text{Gas flow rate (Mm}^3/\text{day)} \]

\[ W = \text{Inlet-outlet H}_2\text{O content (gr/Mm}^3) \]

\[ R = \text{Glycol/water ratio (rule of thumb)} \]

\[ OC = \text{Percent over-circulation} \]

\[ G = \text{Methane entrainment (rule of thumb)} \]
Desiccant Dehydrator Savings: Gas Vented from Pneumatic Controllers

Example:

\[ GE = ? \]
\[ PD = 4 \]
\[ EF = 3.57 \text{ Mm}^3/\text{device/year} \]

Calculate:

\[ GE = EF \times PD \]

\[ GE = 14.27 \text{ Mm}^3/\text{year} \]

Where:

\[ GE = \text{ Annual gas emissions (Mm}^3/\text{year)} \]
\[ PD = \text{ Number of pneumatic devices per dehydrator} \]
\[ EF = \text{ Emission factor} \]
\[ (\text{Mm}^3 \text{ natural gas leakage/ pneumatic devices per year)} \]
Desiccant Dehydrator Savings: Fuel Gas for Glycol Dehydrator

- Gas fuel for glycol reboiler
  - 28 Mm³/day dehydrator
  - Removing 224 gr water/MM³
  - Reboiler heat rate: 313 kJ/L TEG
  - Heat content of natural gas: 38.265 kJ/m³

- Fuel requirement:
  0.48 Mm³/year

- Gas fuel for gas heater
  - 28 Mm³ dehydrator
  - Heat gas from 8ºC to 16ºC
  - Specific heat of natural gas: 1,843 kJ/kg-ºC
  - Density of natural gas: 0,806 kg/m³
  - Efficiency: 70%

- Fuel requirement:
  13.67 Mm³/year
Desiccant Dehydrator Savings: Gas Lost from Desiccant Dehydrator

Example:
GLD = ?
ID = 20 inch (0,508 m)
H = 76.75 inch (1,949 m)
%G = 45%
P₁ = 1 atm
P₂ = 31 atm
T = 7 days

Calculate:
GLD = H * ID² * π * P₂ * %G * 365 days/year
4 * P₁ * T * 1.000 m³/Mm³

GLD = 0,28 Mm³/year

Where:
GLD = Desiccant dehydrator gas loss (Mm³/year)
ID = Inside Diameter (m)
H = Vessel height by vendor specification (m)
%G = Percentage of gas volume in the vessel
P₁ = Atmospheric pressure (atm)
P₂ = Gas pressure (atm)
T = Time between refilling (days)
Desiccant Dehydrator Savings:

Gas vented from glycol dehydrator: 1,95 Mm³/year
Gas vented from pneumatic controls: + 14,27 Mm³/year
Gas burned in glycol reboiler: + 0,48 Mm³/year
Gas burned in gas heater: + 13,67 Mm³/year
Minus desiccant dehydrator vent: - 0,28 Mm³/year

Total savings: 30,09 Mm³/year

Value of gas savings¹: US$2.126/year

¹ Gas valued at US$70,63/Mm³
# Desiccant Dehydrator and Glycol Dehydrator Cost Comparison

## Implementation Costs

<table>
<thead>
<tr>
<th>Type of Costs and Savings</th>
<th>Desiccant (US$/yr)</th>
<th>Glycol (US$/yr)</th>
</tr>
</thead>
<tbody>
<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></td>
<td></td>
</tr>
<tr>
<td>Other costs (installation and engineering)</td>
<td>12.073</td>
<td>18.573</td>
</tr>
<tr>
<td><strong>Total Implementation Costs:</strong></td>
<td><strong>28.169</strong></td>
<td><strong>43.337</strong></td>
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</tbody>
</table>

## Annual Operating and Maintenance Costs

<table>
<thead>
<tr>
<th>Type of Costs and Savings</th>
<th>Desiccant (US$/yr)</th>
<th>Glycol (US$/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desiccant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of desiccant refill US($1,50/pound)</td>
<td>2.556</td>
<td></td>
</tr>
<tr>
<td>Cost of brine disposal</td>
<td>14</td>
<td></td>
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<tr>
<td>Labor cost</td>
<td>1.040</td>
<td></td>
</tr>
<tr>
<td><strong>Total Annual Operation and Maintenance Costs:</strong></td>
<td><strong>3.610</strong></td>
<td><strong>3.260</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Costs and Savings</th>
<th>Desiccant (US$/yr)</th>
<th>Glycol (US$/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of glycol refill (US$4,50/gallon)</td>
<td></td>
<td>206</td>
</tr>
<tr>
<td>Material and labor cost</td>
<td>3.054</td>
<td></td>
</tr>
</tbody>
</table>

Based on 28 Mm³ per day natural gas operating at 30 atm and 8°C

Installation costs assumed at 75% of the equipment cost
Desiccant Dehydrator Economics

- Payback = 8.9 years
  - Without potential carbon market benefits

<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 (US$)</td>
<td>-28.169</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of gas Saved (US$)</td>
<td></td>
<td>2.126</td>
<td>2.126</td>
<td>2.126</td>
<td>2.126</td>
<td>2.126</td>
</tr>
<tr>
<td>Glycol dehy. salvage value (US$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.382</td>
</tr>
<tr>
<td>Total (US$)</td>
<td>-15.787</td>
<td>1.776</td>
<td>1.776</td>
<td>1.776</td>
<td>1.776</td>
<td>1.776</td>
</tr>
</tbody>
</table>

1 Gas price = US$70.63/Mm³
2 Salvage value estimated as 50% of glycol dehydrator capital cost
Industry Experiences

- One Partner installed flash tank separators on its glycol dehydrators
  - Recovers 98% of methane from glycol degassing
  - 34 to 47 Mm$^3$/year reductions per dehydrator
  - US$2.370 to US$3.318/year$^1$ savings per dehydrator

- Another Partner routes gas from flash tank separator to fuel gas system
  - 248 Mm$^3$/year reductions per dehydrator
  - US$17.520/year$^1$ savings per dehydrator

$^1$ Gas valued at $70.63/Mm$^3$
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
- 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
- Miscellaneous other PROs can have big savings
Miscellaneous Other PROs

- Available in Spanish language at epa.gov/gasstar/tools/spanish/index.html
Discussion

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