Natural Gas Dehydration

Lessons Learned
from Natural Gas STAR

Producers and Processors
Technology Transfer Workshop

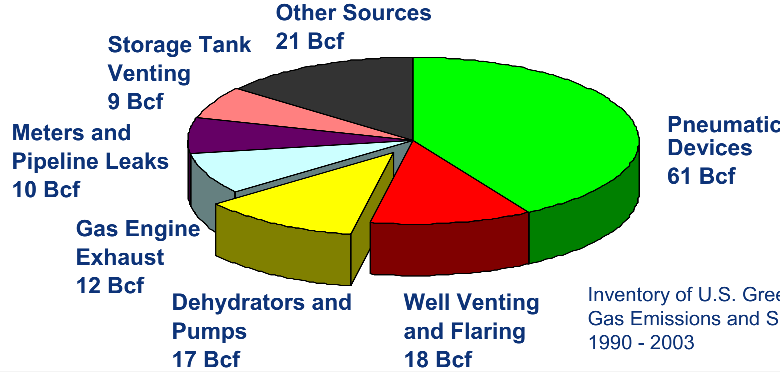
Western Gas Resources and
EPA's Natural Gas STAR Program
Gillette and Rock Springs, WY
May 9 & 11, 2006

Natural Gas Dehydration: Agenda

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

Methane Losses from Dehydrators

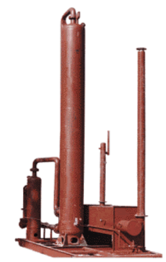
- Dehydrators and pumps account for:
  - 17 Bcf of methane emissions in the production, gathering, and boosting sector
  - 1 Bcf of methane emissions in the processing sector



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

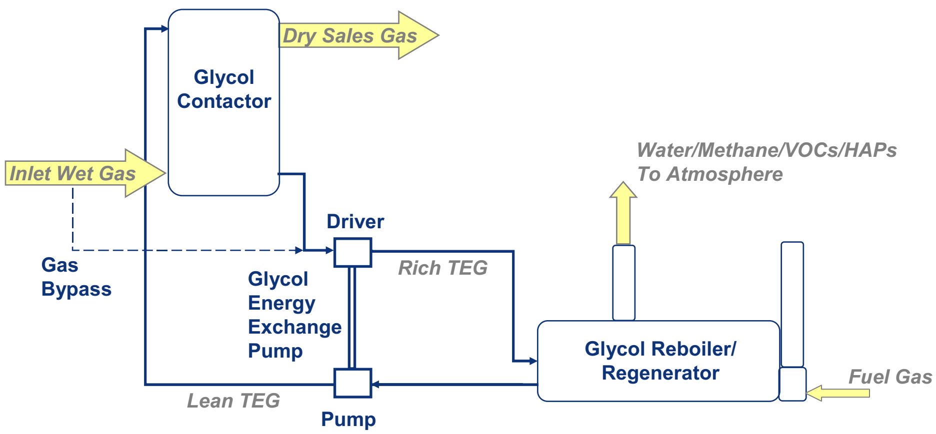
What is the Problem?

- 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
  - 32,000 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



Methane Recovery: Five Options

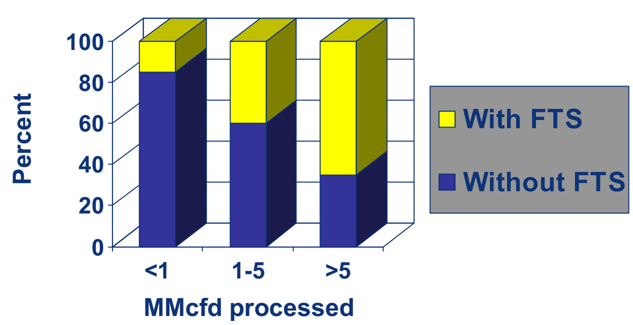
- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Zero emission dehydrator
- Replace glycol unit with desiccant dehydrator
- Flare (no recovery)

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)

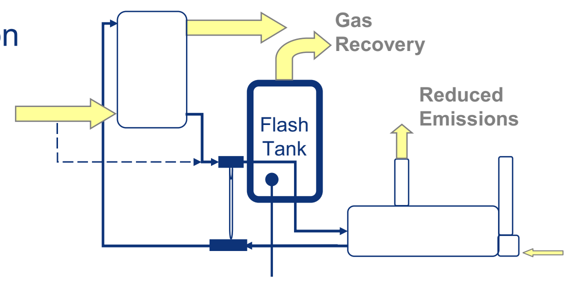
- Flashed methane can be captured using an FTS
- Many units are not using an FTS



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

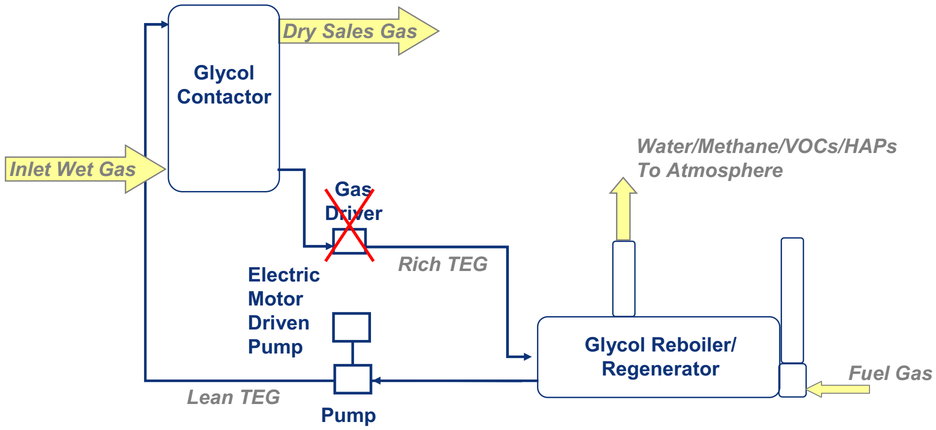


Low Capital Cost/Quick Payback

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



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

Option	Capital Costs	Annual O&M Costs	Emissions Savings	Payback Period[1]
Optimize Circulation Rate	Negligible	Negligible	130 – 13,133 Mcf/year	Immediate
Install Flash Tank	$5,000 - $10,000	Negligible	236 – 7,098 Mcf/year	2 months – 6 years
Install Electric Pump	$4,200 - $23,400	$3,600	360 – 36,000 Mcf/year	< 1 month – several years

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

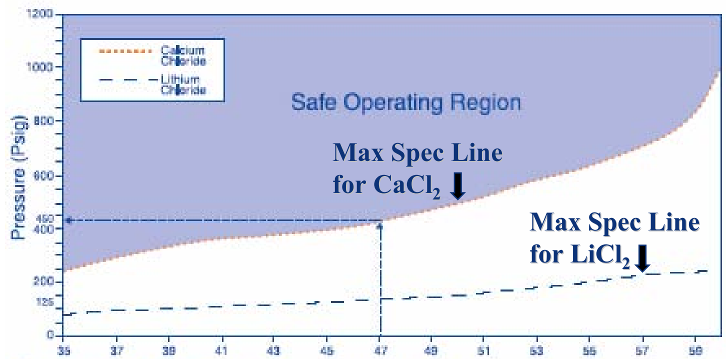
Replace Glycol Unit with Desiccant Dehydrator

- 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

Hygroscopic Salts	Typical T and P for Pipeline Spec	Cost
Calcium chloride	47°F 440 psig	Least expensive
Lithium chloride	60°F 250 psig	More expensive

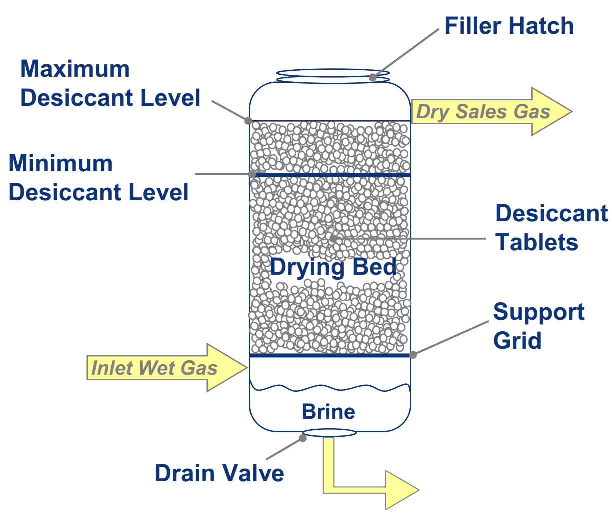
Desiccant Performance

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



Source: Air & Vacuum Process, Inc.

Desiccant Dehydrator Schematic



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:	**Where:**
D = ?	D = Amount of desiccant needed (pounds/day)
F = 1 MMcf/day	F = Gas flow rate (MMcf/day)
I = 21 pounds/MMcf	I = Inlet water content (pounds/MMcf)
O = 7 pounds/MMcf	O = Outlet water content (pounds/MMcf)
B = 1/3	B = Desiccant/water ratio vendor rule of thumb

Calculate:

$D = F * (I - O) * B$

$D = 1 * (21 - 7) * 1/3$

$D = \boxed{4.7 \text{ pounds desiccant/day}}$

Source: Van Air

Note:
MMcf = Million Cubic Feet

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:

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

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:	Where:
GV = ?	GV= Gas vented annually (Mcf/year)
F = 1 MMcf/day	F = Gas flow rate (MMcf/day)
W = 21-7 pounds H_2O/MMcf	W = Inlet-outlet H_2O content (pounds/MMcf)
R = 3 gallons/pound	R = Glycol/water ratio (rule of thumb)
OC = 150%	OC = Percent over-circulation
G = 3 cf/gallon	G = Methane entrainment (rule of thumb)

Calculate:

$$GV = \frac{(F * W * R * OC * G * 365 \text{ days/year})}{1{,}000 \text{ cf/Mcf}}$$

GV = 69 Mcf/year

Glycol Dehydrator Unit
Source: GasTech

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 bleed/ pneumatic devices per year)

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

Norriseal Pneumatic Liquid Level Controller

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%
P_1 = 15 Psia
P_2 = 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
P_1 = Atmospheric pressure (Psia)
P_2 = Gas pressure (Psig)
T = Time between refilling (days)

Calculate:

$$GLD = \frac{H * ID^2 * \pi * P_2 * \%G * 365 \text{ days/year}}{4 * P_1 * T * 1{,}000 \text{ cf/Mcf}}$$

GLD = 10 Mcf/year

Desiccant Dehydrator Unit
Source: usedcompressors.com

Desiccant Dehydrator and Glycol Dehydrator Cost Comparison

Type of Costs and Savings	Desiccant ($/yr)	Glycol ($/yr)
Implementation Costs		
Capital Costs		
Desiccant (includes the initial fill)	13,000	
Glycol		20,000
Other costs (installation and engineering)	9,750	15,000
Total Implementation Costs:	22,750	35,000
Annual Operating and Maintenance Costs		
Desiccant		
Cost of desiccant refill ($1.20/pound)	2,059	
Cost of brine disposal	14	
Labor cost	1,560	
Glycol		
Cost of glycol refill ($4.50/gallon)		167
Material and labor cost		4,680
Total Annual Operation and Maintenance Costs:	**3,633**	**4,847**

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

Type of Costs and Savings	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital costs	-$22,750					
Avoided O&M costs		$4,847	$4,847	$4,847	$4,847	$4,847
O&M costs - Desiccant		-$3,633	-$3,633	-$3,633	-$3,633	-$3,633
Value of gas saved [1]		$7,441	$7,441	$7,441	$7,441	$7,441
Glycol dehy. salvage value [2]	$10,000					
Total	-$12,750	$8,655	$8,655	$8,655	$8,655	$8,655

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?