Natural Gas Dehydration

Lessons Learned
from Natural Gas STAR

Producers and Processors
Technology Transfer Workshop

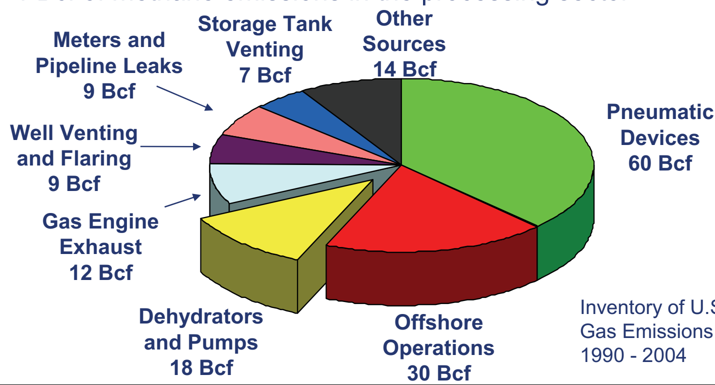
ConocoPhillips and
EPA's Natural Gas STAR Program
Kenai, AK
May 25, 2006

Natural Gas Dehydration: Agenda

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

Methane Losses from Dehydrators

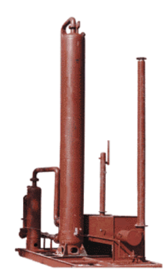
- Dehydrators and pumps account for:
  - 18 Bcf of methane emissions in the production, gathering, and boosting sector
  - 1 Bcf of methane emissions in the processing sector



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2004

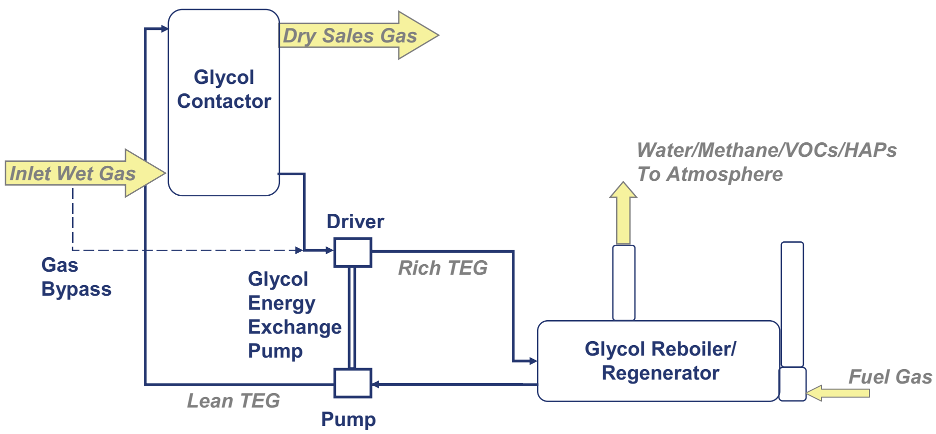
What is the Problem?

- 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



Methane Recovery: Five Options

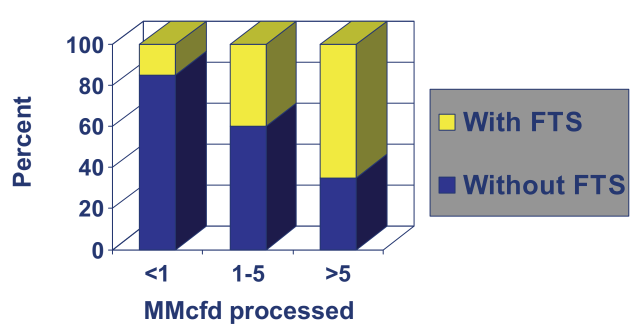
- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Zero emission dehydrator
- Replace glycol unit with desiccant dehydrator
- Flare (no recovery)

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)

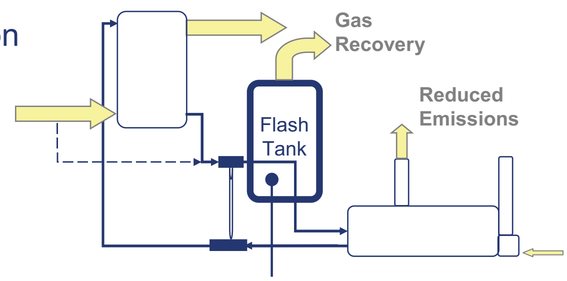
- Flashed methane can be captured using an FTS
- Many units are not using an FTS



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

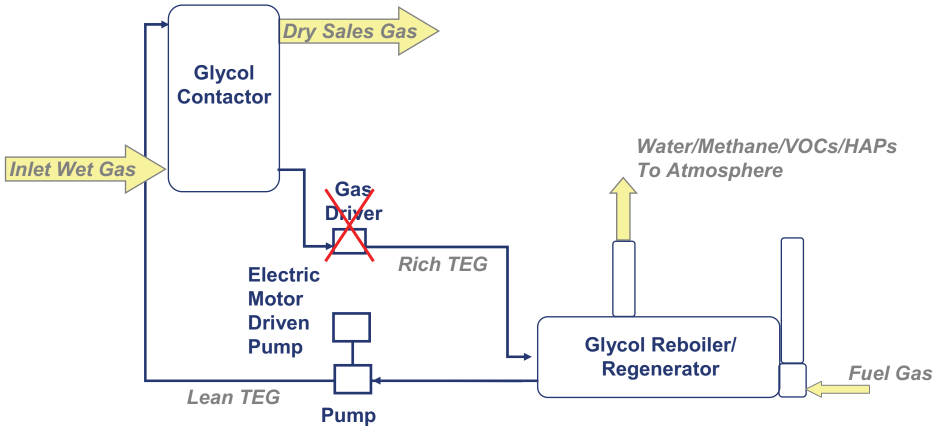


Low Capital Cost/Quick Payback

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^{o}F 440 psig	Least expensive
Lithium chloride	60^{o}F 250 psig	More expensive

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

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
- 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
- FTS reduces methane emissions by ~ 90 percent
  - Require a low pressure gas outlet, one option is a VRU

Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use rotary compressor to suck vapors out of atmospheric pressure storage tanks
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU™ requires source of high pressure gas and intermediate pressure system
  - Vapor Jet requires high pressure water motive

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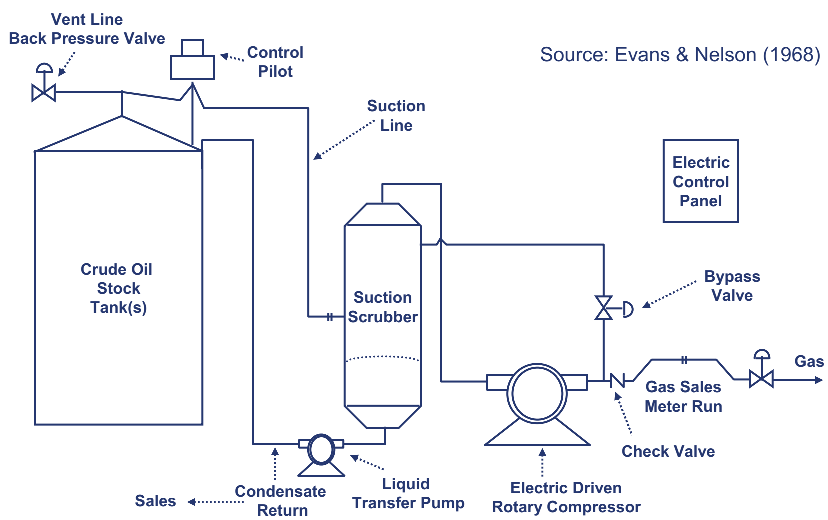
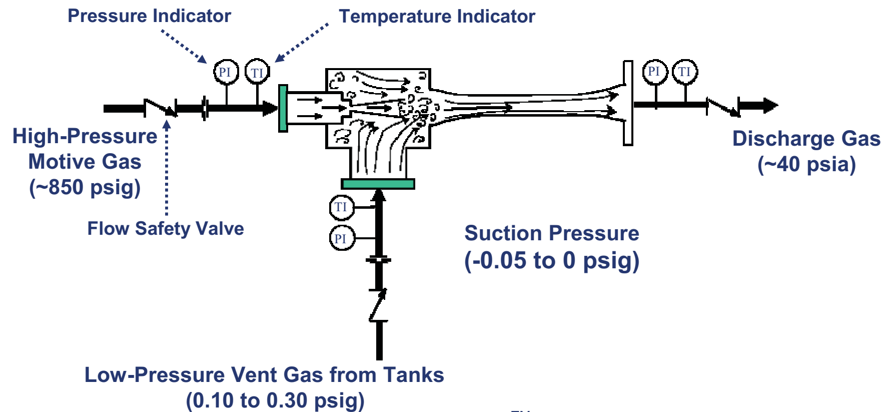
Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)



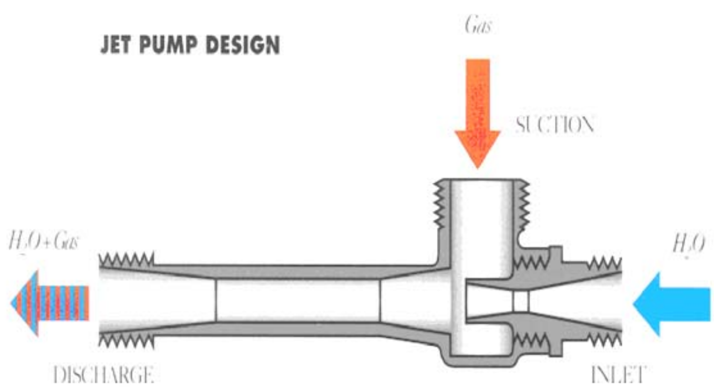
Venturi Jet Ejector*



*EVRU[TM] Patented by COMM Engineering

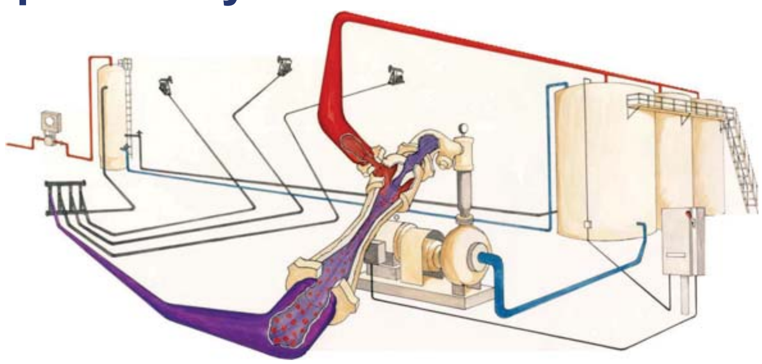
Adapted from SRI/USEPA-GHG-VR-19
psig = pound per square inch, gauge
psia = pounds per square inch, atmospheric

Vapor Jet System*



*Patented by Hy-Bon Engineering

Vapor Jet System*



- Utilizes produced water in closed loop system to effect gas gathering from tanks
- Small centrifugal pump forces water into Venturi jet, creating vacuum effect
- Limited to gas volumes of 77 Mcf / day and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering

Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps
- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system
- Tank batteries not subject to air regulations

Vapor Recovery Installations

Vapor Recovery Installations

What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated

Is Recovery Profitable?

Financial Analysis for a conventional VRU Project						
Peak Capacity (Mcf / day)	Installation & Capital Costs[1]	O & M Costs ($ / year)	Value of Gas[2] ($ / year)	Annual Savings	Simple Payback (months)	Return on Investment
25	26,470	5,250	$ 51,465	$ 46,215	7	175%
50	34,125	6,000	$ 102,930	$ 96,930	5	284%
100	41,125	7,200	$ 205,860	$ 198,660	3	483%
200	55,125	8,400	$ 411,720	$ 403,320	2	732%
500	77,000	12,000	$ 1,029,300	$ 1,017,300	1	1321%

1 Unit Cost plus estimated installation at 75% of unit cost

2 $11.28 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

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?