Natural Gas Dehydration

Lessons Learned
from Natural Gas STAR

Producers Technology Transfer Workshop

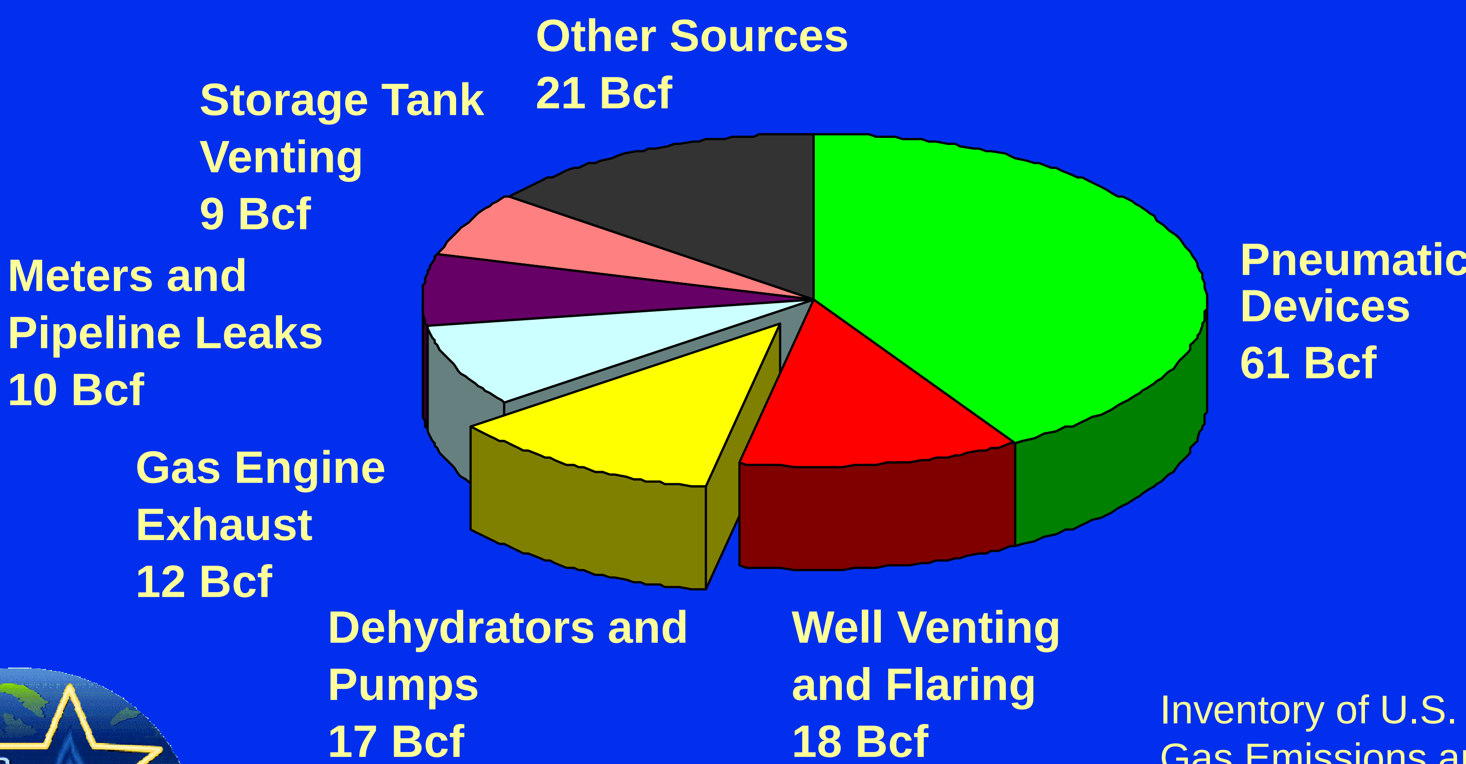
Devon Energy and
EPA's Natural Gas STAR Program
Casper, Wyoming
August 30, 2005

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



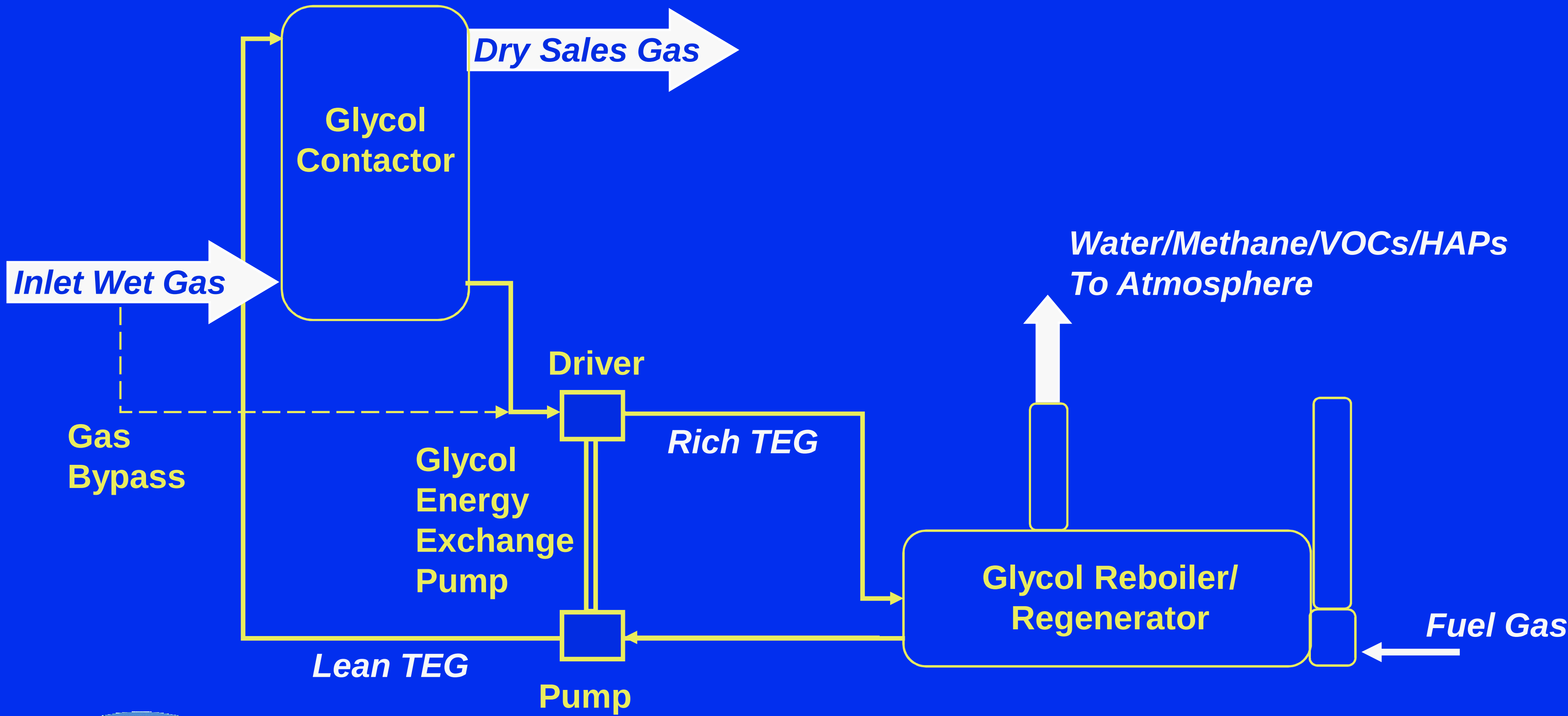
Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

What is the Problem?

- ✮ Produced gas is saturated with water, which must be removed for gas 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



Methane Recovery: Four Options

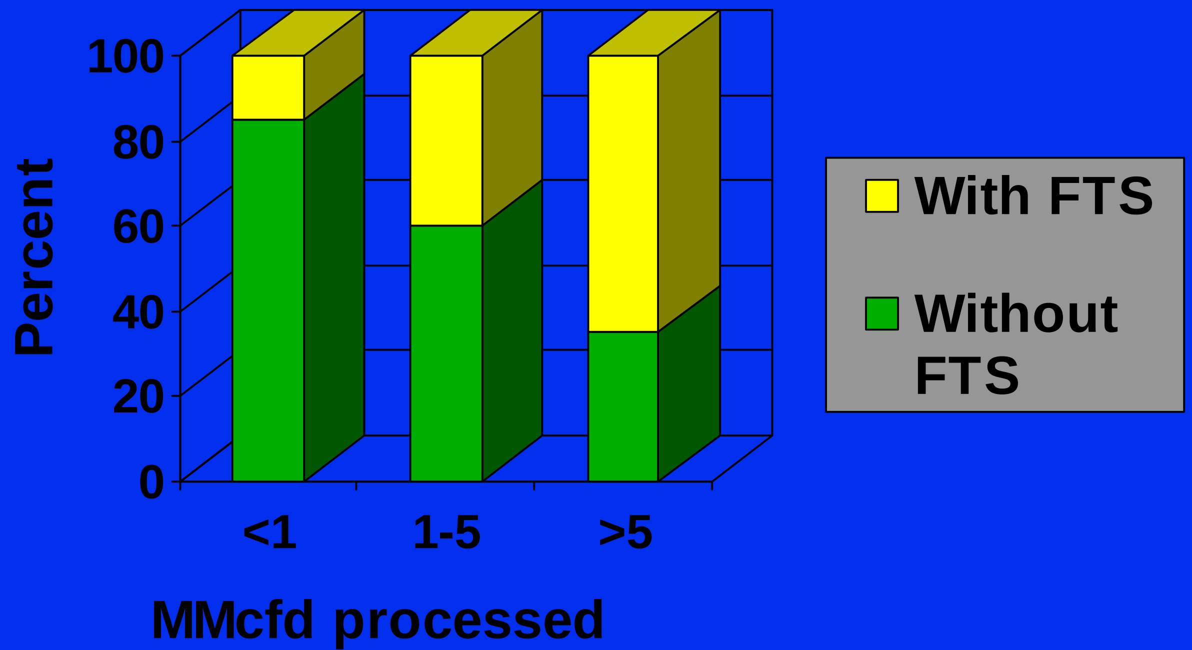
- Optimized glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Replace glycol unit with desiccant dehydrator

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**

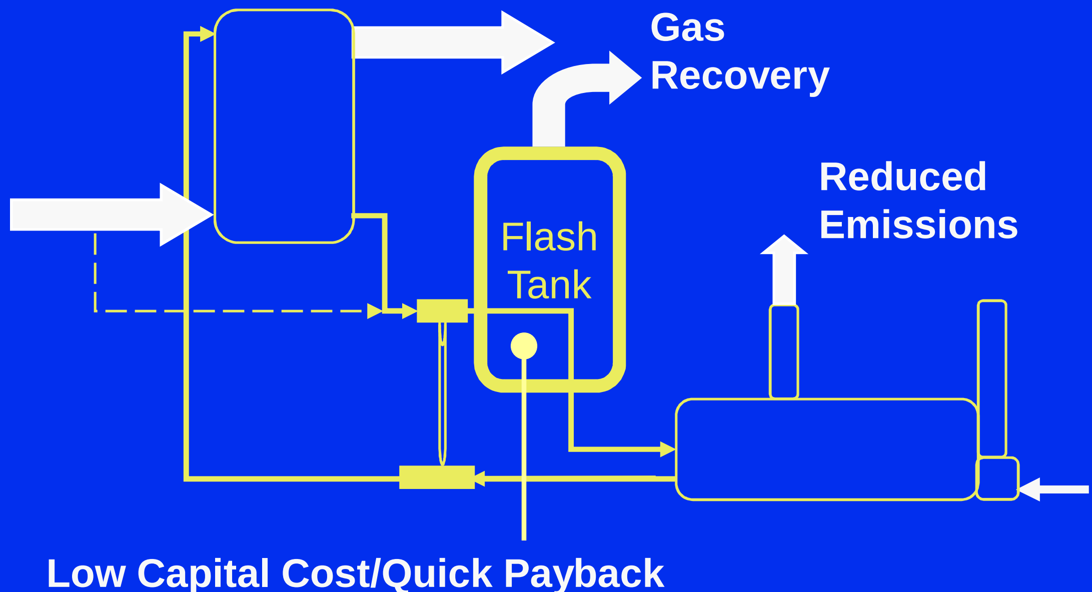
Installing Flash Tank Separator

- Flashed methane can be captured using an FTS
- Many units are <u>not</u> using an FTS



Methane Recovery

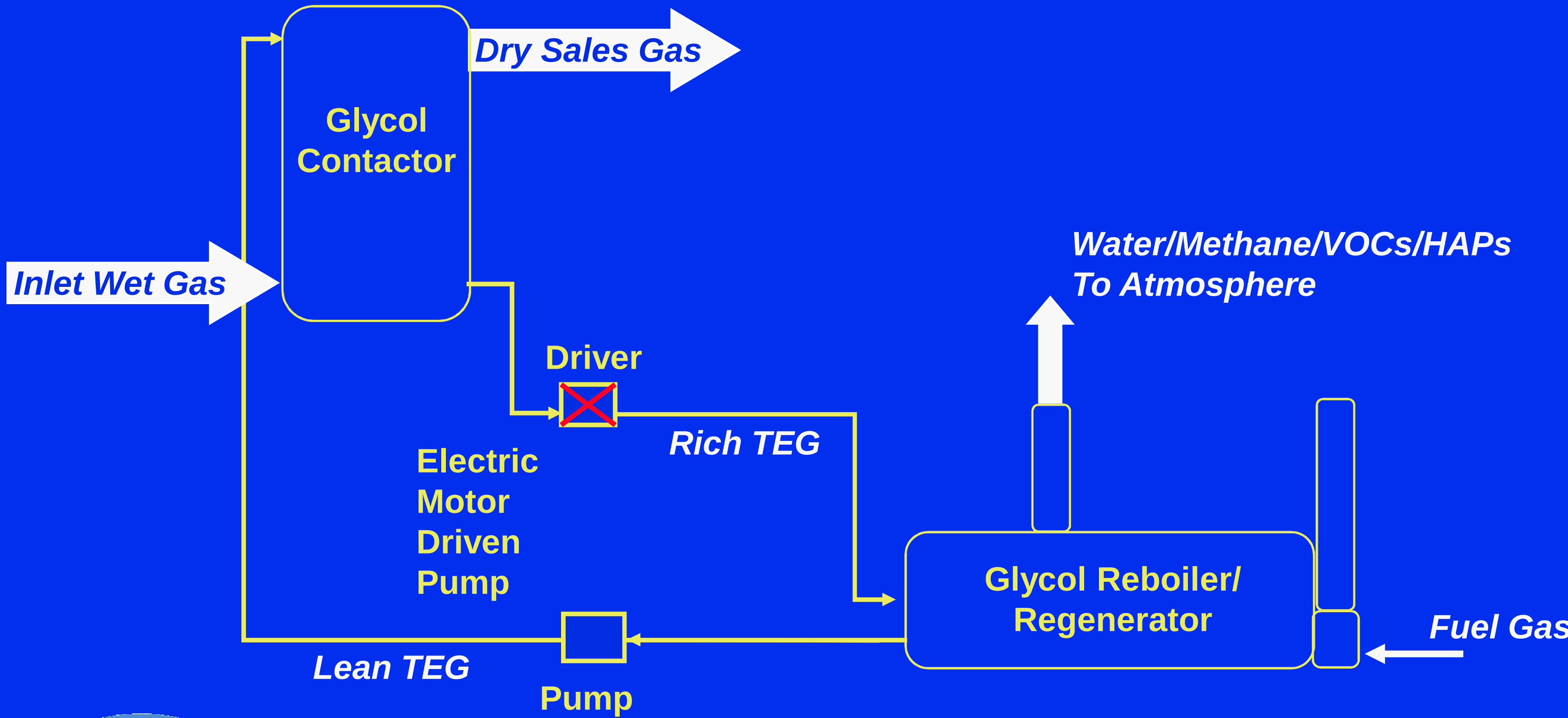
- Recovers ~ 90% of methane emissions
- Reduces VOCs by 10 to 90%
- Must have an outlet for low pressure gas



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

Is Recovery Profitable?

Three Options for Minimizing Glycol Dehydrator Emissions

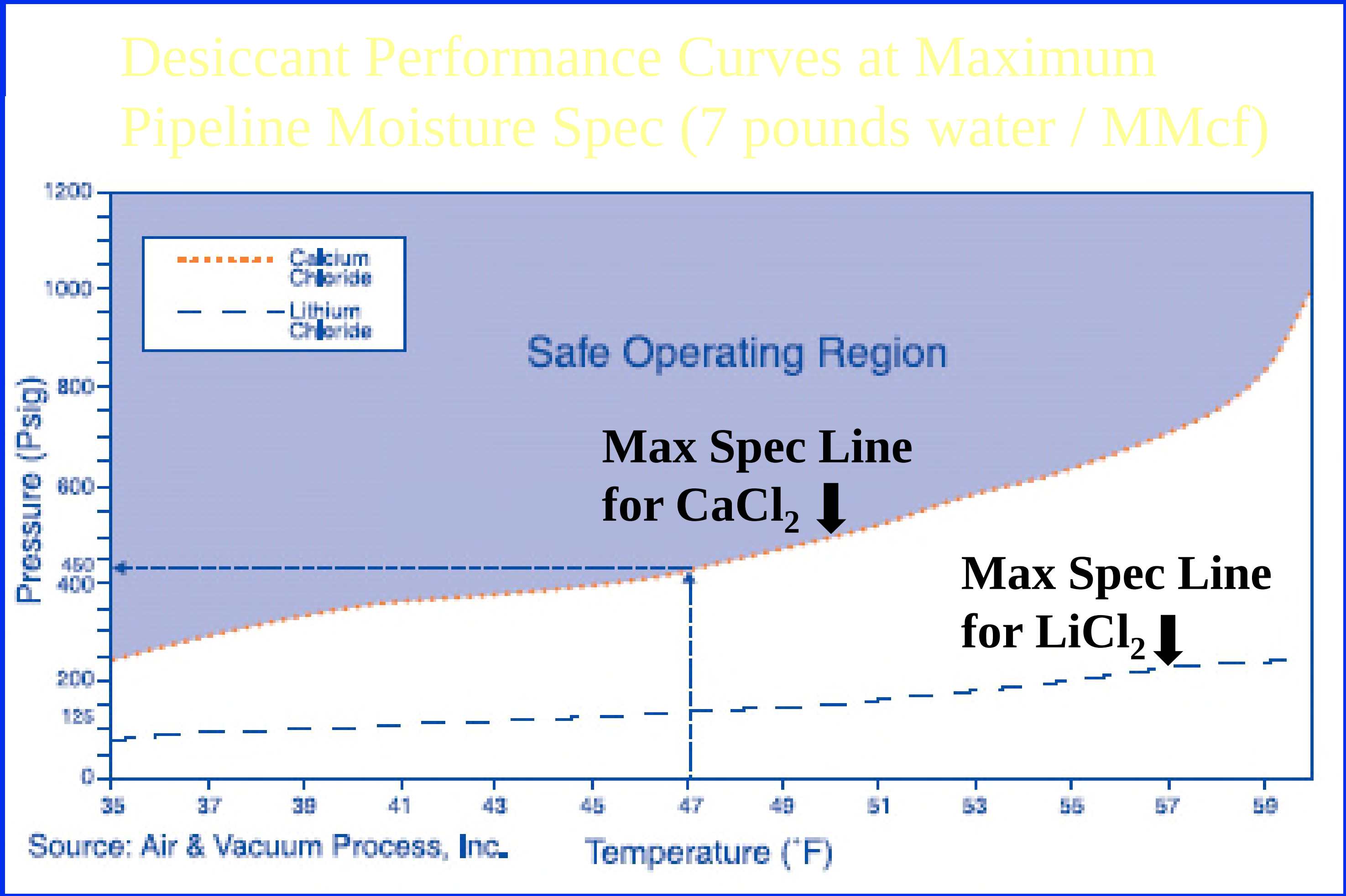
Option	Capital Costs	Annual O&M Costs	Emissions Savings	Payback Period
Optimize Circulation Rate	Negligible	Negligible	130 – 13,133 Mcf/year	Immediate
Install Flash Tank	$5,000 - $10,000	Negligible	236 – 7,098 Mcf/year	5 months – 17 months
Install Electric Pump	$4,200 - $23,400	$3,600	360 – 36,000 Mcf/year	< 2 months – several years

Replace Glycol Unit with Desiccant Dehydrator

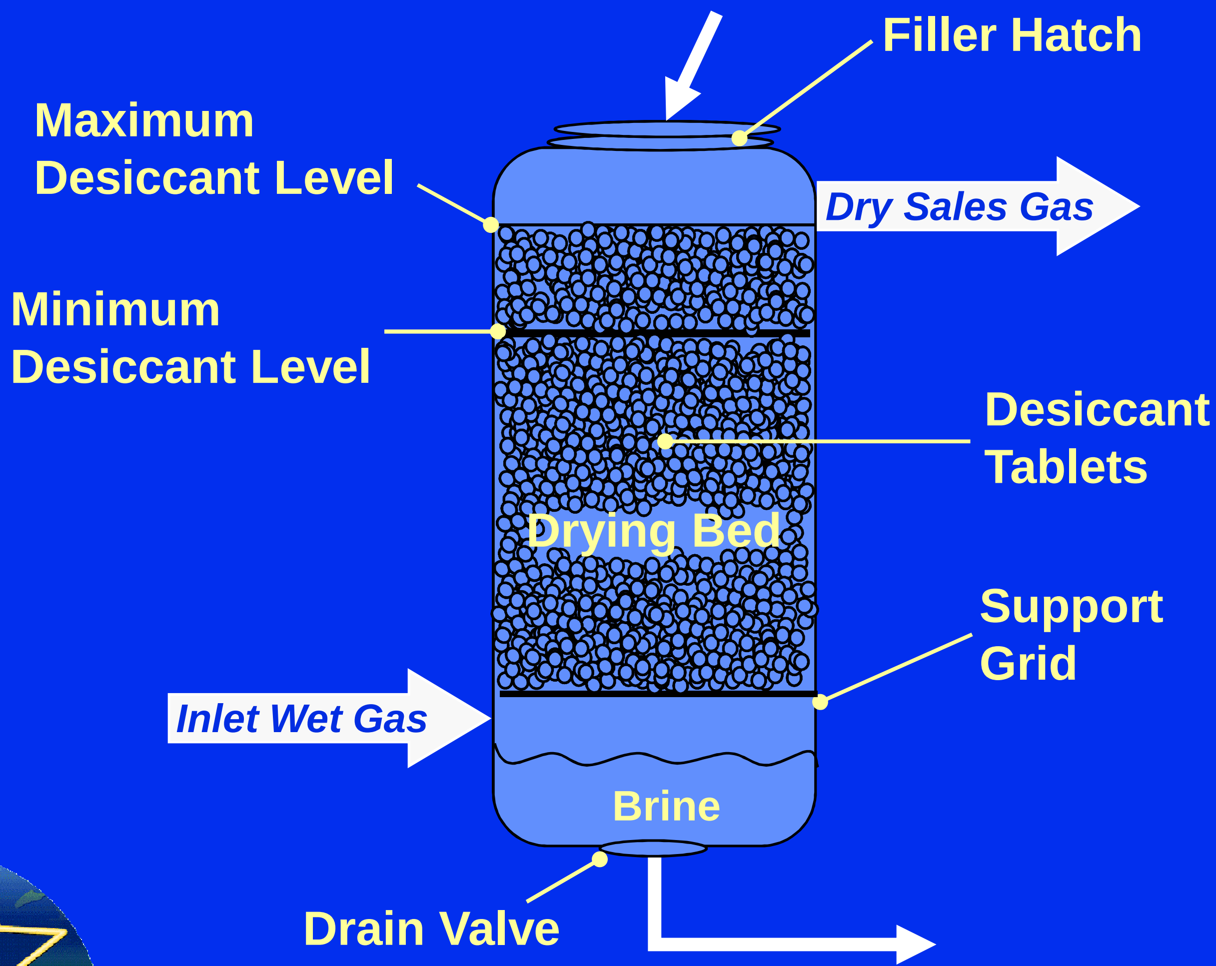
- Desiccant Dehydrator
  - **Wet gasses pass through drying bed of desiccant tablets**
  - **Tablets absorb moisture from gas and dissolve**
- Moisture removal depends on:
  - **Type of desiccant (salt)**
  - **Gas temperature and pressure**

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 Dehydrator Schematic



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

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

Source: Van Air

Note:
MMcf = Million Cubic Feet

Calculate Vessel Inside 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:

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

Commercially ID available = 20 inch

Source: Van Air

Note:
cf = Cubic Feet

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_2O/MMcf

R = 3 gallons/pound

OC = 150%

G = 3 cf/gallon

Where:

GV= Gas vented annually (Mcf/year)

F = Gas flow rate (MMcf/day)

W = Inlet-outlet H_2O content (pounds/MMcf)

R = Glycol/water ratio (rule of thumb)

OC = Percent over-circulation

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 leakage/ 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

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?