Methane to Markets

Natural Gas Dehydrator Optimization

IAPG & US EPA Technology Transfer Workshop

November 5, 2008
Buenos Aires, Argentina

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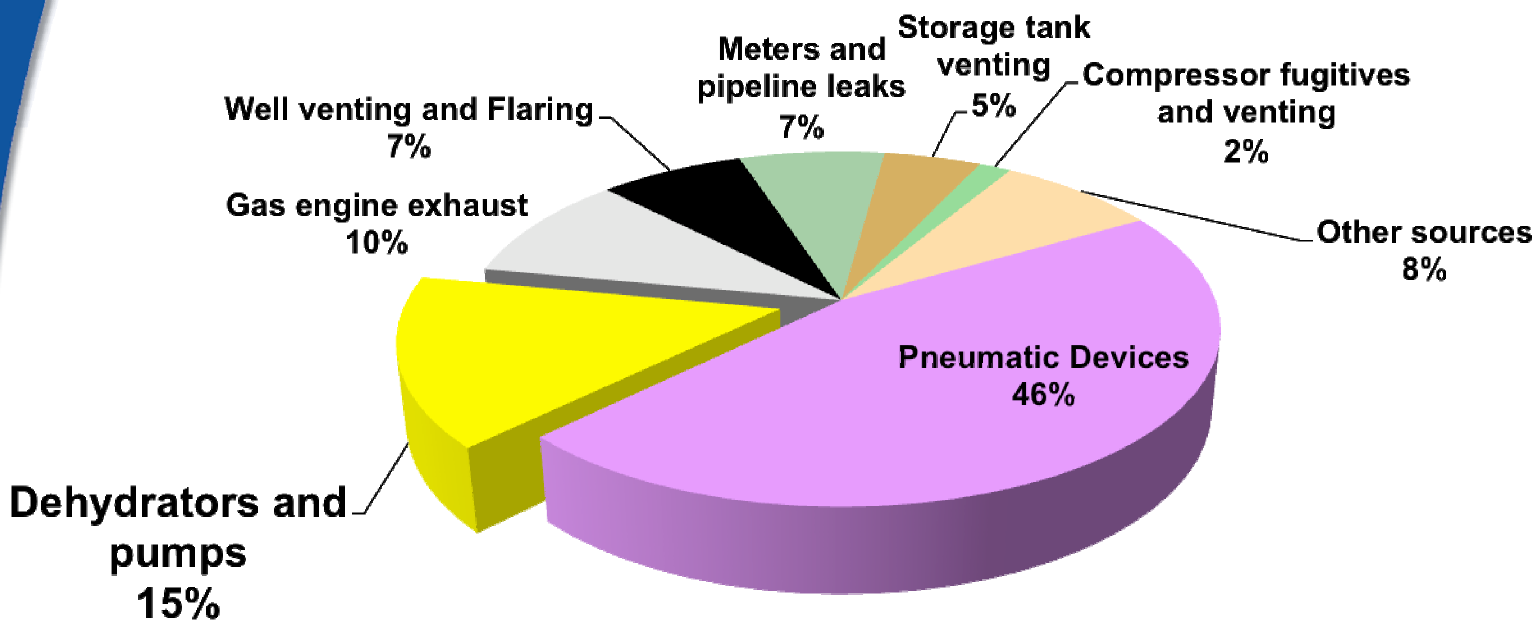
Natural Gas Dehydration: Agenda

- 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)



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2005.* April, 2007. Available on the web at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissions.html
Natural Gas STAR reductions data shown as published in the inventory.

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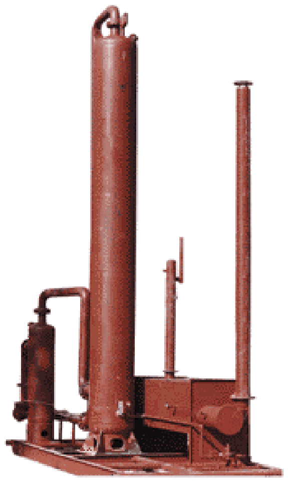
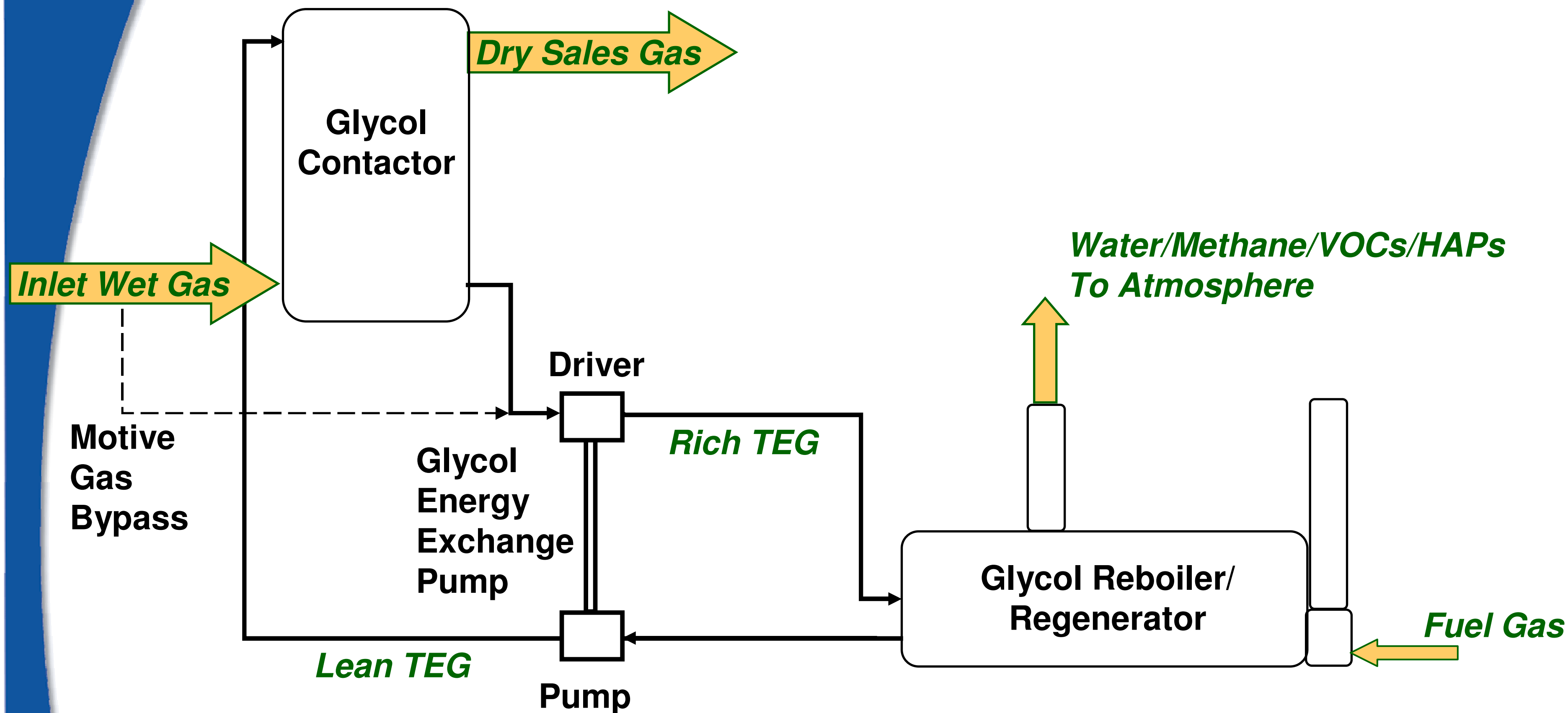
What is the Problem?

- 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



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Methane Recovery Options

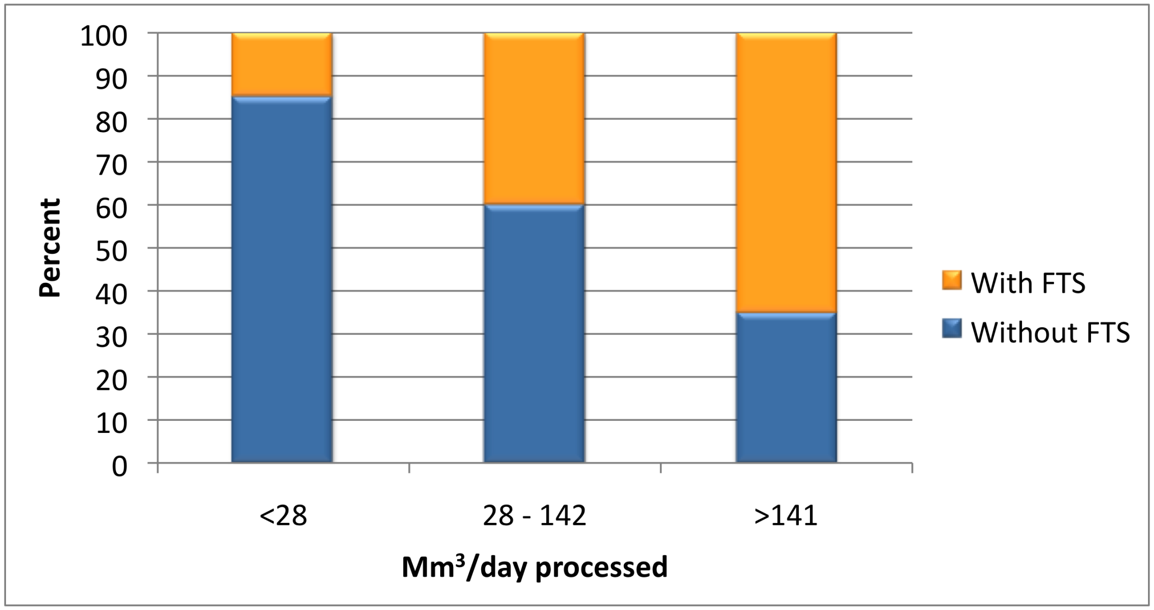
- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric pump installation
- Zero emission dehydrator
- Replace glycol unit with desiccant dehydrator
- Other opportunities

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

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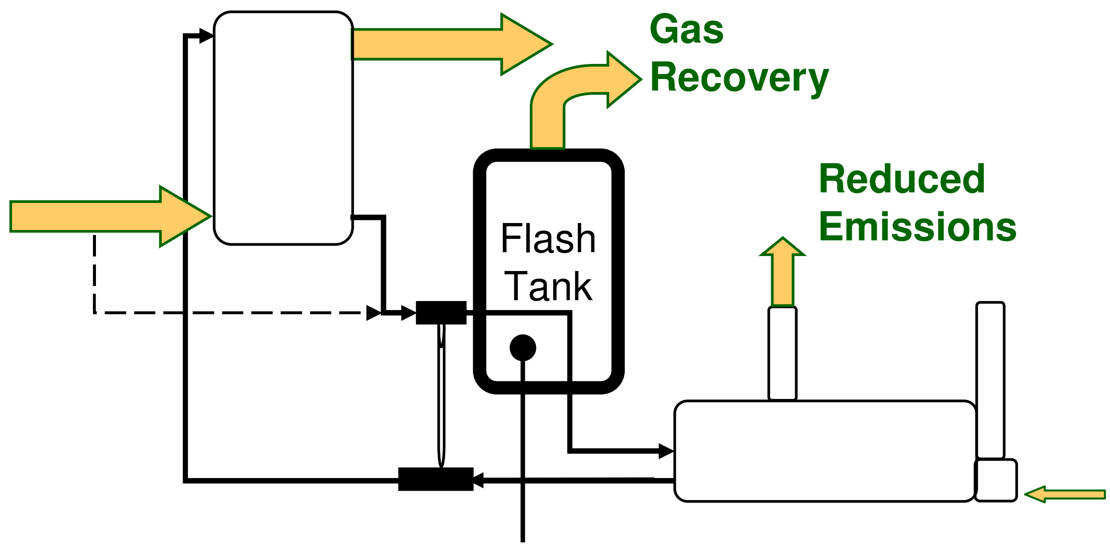
FTS Methane Recovery

- 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



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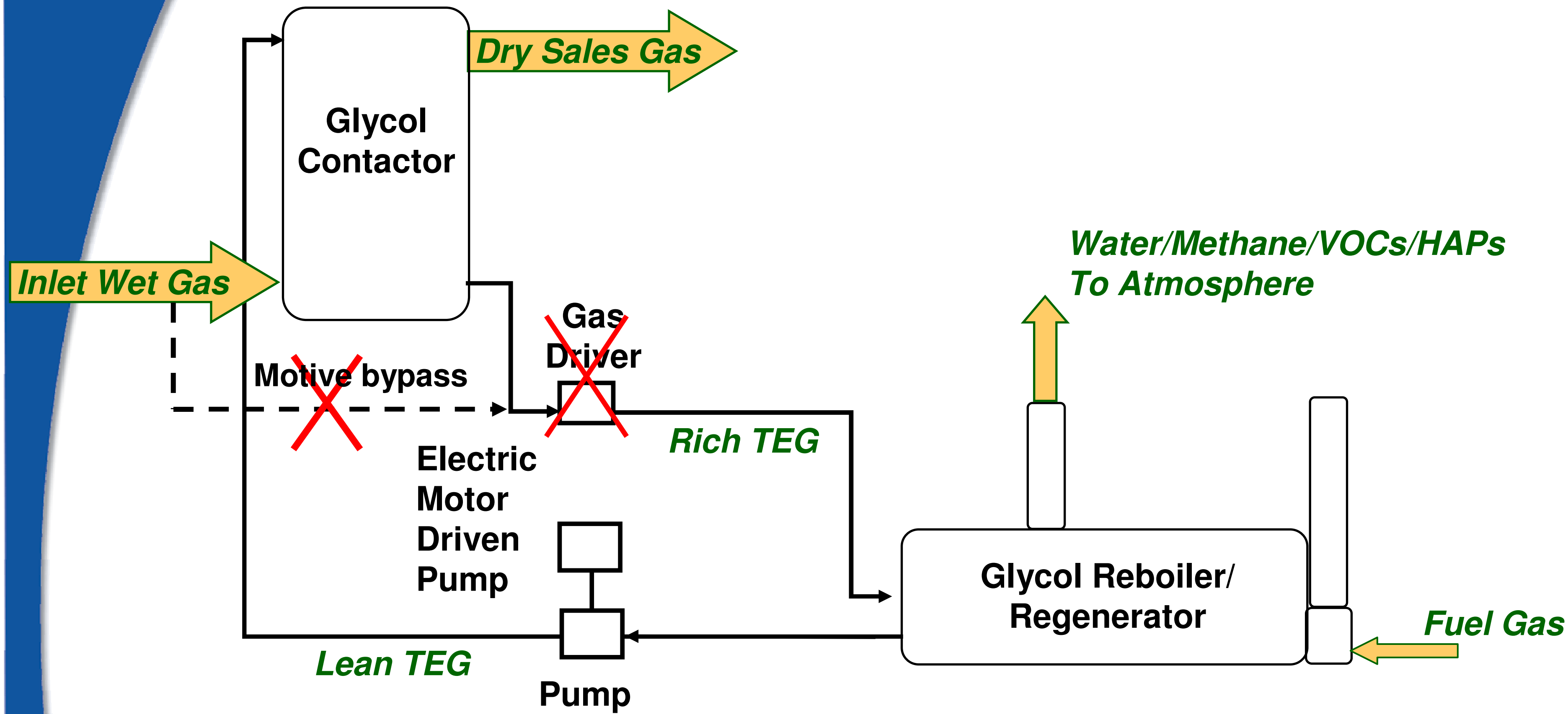
Flash Tank Costs

- 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



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Is Recovery Profitable?

- Three options for minimizing glycol dehydrator emissions

Option	Capital Costs (US$)	Annual O&M Costs (US$)	Emissions Savings (Mm^3/year)	Payback Period[1]
Optimize Circulation Rate	Negligible	Negligible	11 to 1.116	Immediate
Install Flash Tank	6.500 to 18.800	Negligible	20 to 301	0,9 to 4,6 years
Install Electric Pump	1.400 to 13.000	165 to 4.300	10 to 1.019	< 1 year to several years

[1] Gas price of US$70,63/Mm^3

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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

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Zero Emission Dehydrator

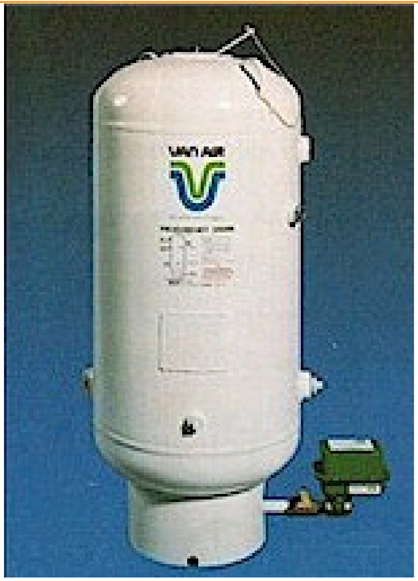
- Combines many emission saving technologies into one unit
  - Vapors in the still gas coming off of the glycol reboiler are condensed in a heat exchanger
  - Non-condensable skimmer gas is routed back to the reboiler for fuel use
  - Electric driven glycol circulation pumps used instead of energy-exchange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

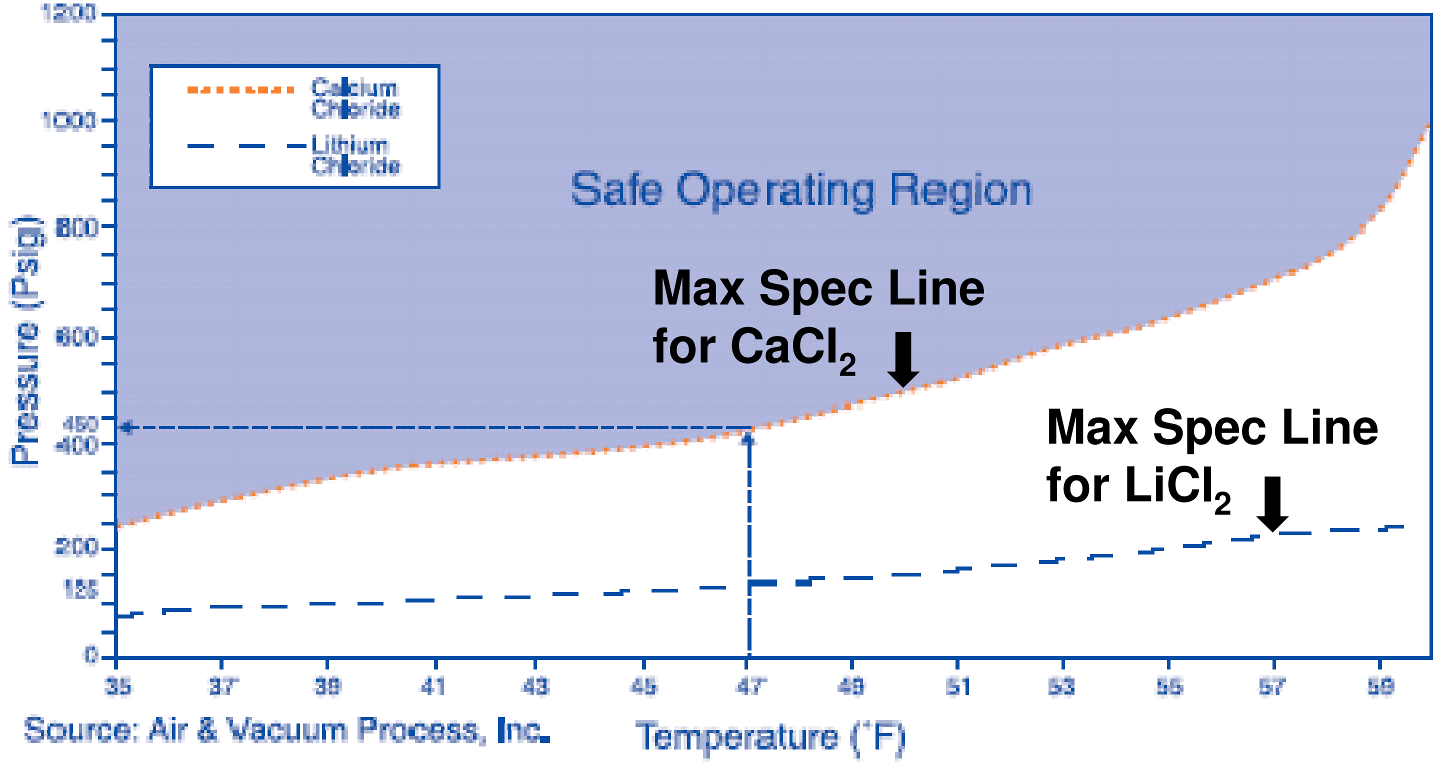


Source: Van Air

Hygroscopic Salts	Typical T and P for Pipeline Spec	Cost
Calcium chloride	<8^{o}C @ 30 atm	Least expensive
Lithium chloride	<16^{o}C @ 17 atm	More expensive

Desiccant Performance

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



Source: Air & Vacuum Process, Inc.

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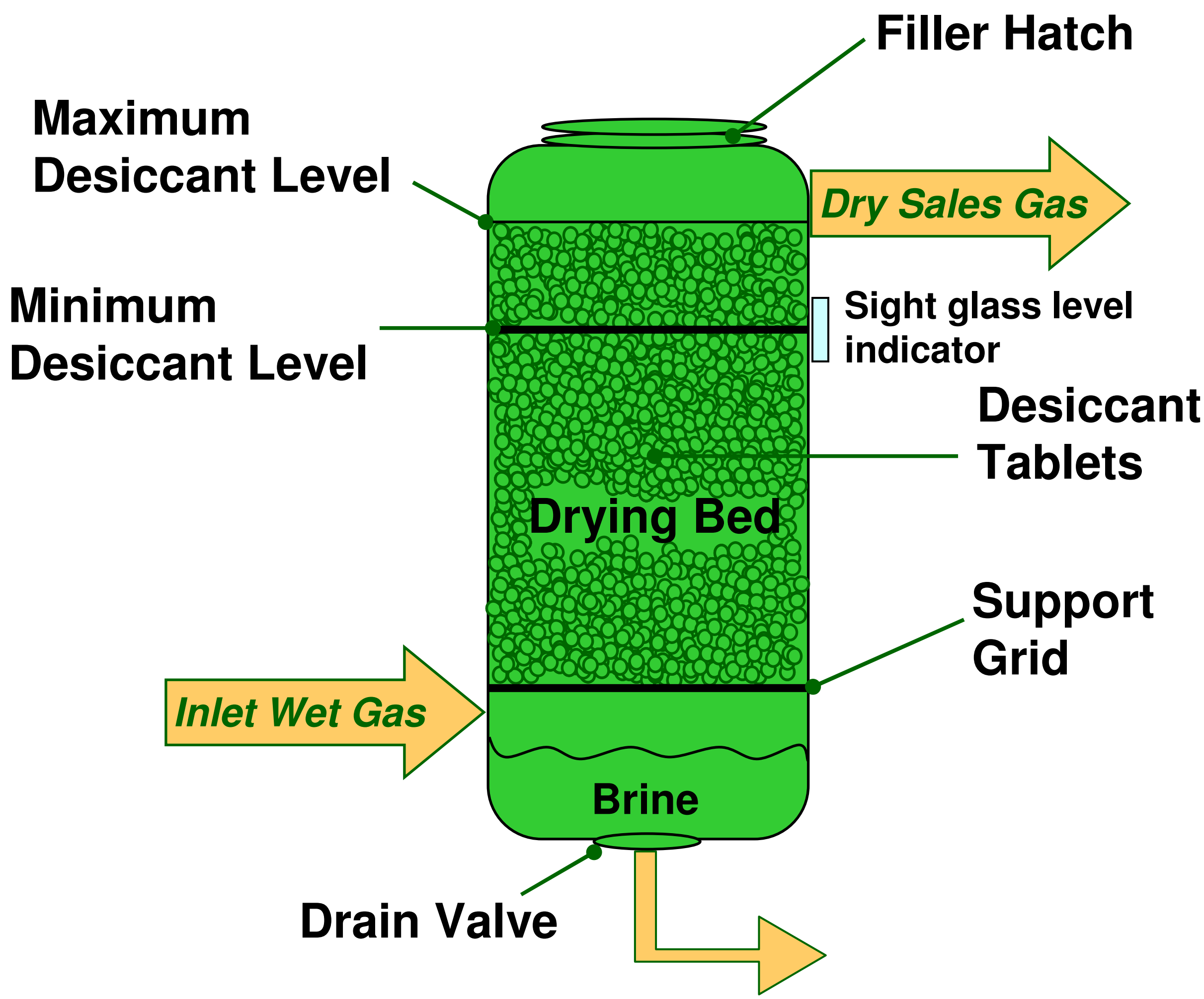
Desiccant Dehydrator Scheme



Desiccant Dehydrator Savings: Gas Vented from Glycol Dehydrator

Example:

GV = ?
F = 28,32 Mm^3/day
W = 336-112 gr H_2O/Mm^3
R = 0,025 L/gr
OC = 150%
G = 0,022 m^3/L

Where:

GV= Gas vented annually (Mm^3/year)
F = Gas flow rate (Mm^3/day)
W = Inlet-outlet H_2O content (gr/Mm^3)
R = Glycol/water ratio (rule of thumb)
OC = Percent over-circulation
G = Methane entrainment (rule of thumb)

Calculate:

$$GV = \frac{(F * W * R * OC * G * 365 \text{days/year})}{1.000\ m^3/Mm^3}$$

GV = **1,95 Mm^3/year**

Glycol Dehydrator Unit
Source: GasTech

Desiccant Dehydrator Savings: Gas Vented from Pneumatic Controllers

Example:

GE = ?

PD = 4

EF = 3,57 Mm^3/device/year

Where:

GE = Annual gas emissions (Mm^3/year)

PD = Number of pneumatic devices per dehydrator

EF = Emission factor (Mm^3 natural gas leakage/ pneumatic devices per year)

Calculate:

GE = EF * PD

GE = **14,27 Mm^3/year**

Norriseal Pneumatic Liquid Level Controller

Source: norriseal.com

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Desiccant Dehydrator Savings: Fuel Gas for Glycol Dehydrator

- Gas fuel for glycol reboiler
  - 28 Mm^3/day dehydrator
  - Removing 224 gr water/Mm^3
  - Reboiler heat rate: 313 kJ/L TEG
  - Heat content of natural gas: 38.265 kJ/m^3
- Fuel requirement:

0,48 Mm^3/year

- Gas fuel for gas heater
  - 28 Mm^3 dehydrator
  - Heat gas from 8ºC to 16ºC
  - Specific heat of natural gas: 1,843 kJ/kg-ºC
  - Density of natural gas: 0,806 kg/m^3
  - Efficiency: 70%
- Fuel requirement:

13,67 Mm^3/year

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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%

P_1 = 1 atm

P_2 = 31 atm

T = 7 days

Where:

GLD = Desiccant dehydrator gas loss (Mm^3/year)

ID = Inside Diameter (m)

H = Vessel height by vendor specification (m)

%G = Percentage of gas volume in the vessel

P_1 = Atmospheric pressure (atm)

P_2 = Gas pressure (atm)

T = Time between refilling (days)

Calculate:

$$GLD = \frac{H * ID^2 * \pi * P_2 * \%G * 365 \text{ days/year}}{4 * P_1 * T * 1.000 \text{ m}^3/\text{Mm}^3}$$

GLD = **0,28 Mm^3/year**

Desiccant Dehydrator Unit
Source: usedcompressors.com

Desiccant Dehydrator Savings:

Gas vented from glycol dehydrator:	1,95 Mm^3/year
Gas vented from pneumatic controls:	+ 14,27 Mm^3/year
Gas burned in glycol reboiler:	+ 0,48 Mm^3/year
Gas burned in gas heater:	+ 13,67 Mm^3/year
Minus desiccant dehydrator vent:	- 0,28 Mm^3/year
Total savings:	30,09 Mm^3/year
Value of gas savings[1]:	US$2.126/year

[1] Gas valued at US$70,63/$Mm^3$

Desiccant Dehydrator and Glycol Dehydrator Cost Comparison

Type of Costs and Savings	Desiccant (US$/yr)	Glycol (US$/yr)
Implementation Costs		
Capital Costs		
Desiccant (includes the initial fill)	16.097	
Glycol		24.764
Other costs (installation and engineering)	12.073	18.573
Total Implementation Costs:	28.169	43.337
Annual Operating and Maintenance Costs		
Desiccant		
Cost of desiccant refill US($1,50/pound)	2.556	
Cost of brine disposal	14	
Labor cost	1.040	
Glycol		
Cost of glycol refill (US$4,50/gallon)		206
Material and labor cost		3.054
Total Annual Operation and Maintenance Costs:	**3.610**	**3.260**

Based on 28 Mm^3 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

Type of Costs and Savings	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Capital costs (US$)	-28.169					
Avoided O&M costs (US$)		3.260	3.260	3.260	3.260	3.260
O&M costs - Desiccant (US$)		-3.610	-3.610	-3.610	-3.610	-3.610
Value of gas Saved [1] (US$)		2.126	2.126	2.126	2.126	2.126
Glycol dehy. salvage value [2] (US$)	12.382					
Total (US$)	-15.787	1.776	1.776	1.776	1.776	1.776

[1] Gas price = US$70,63/$Mm^3$

[2] Salvage value estimated as 50% of glycol dehydrator capital cost

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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$

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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

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Discussion

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