

# LNG Dehydration(Drying of Natural Gas)

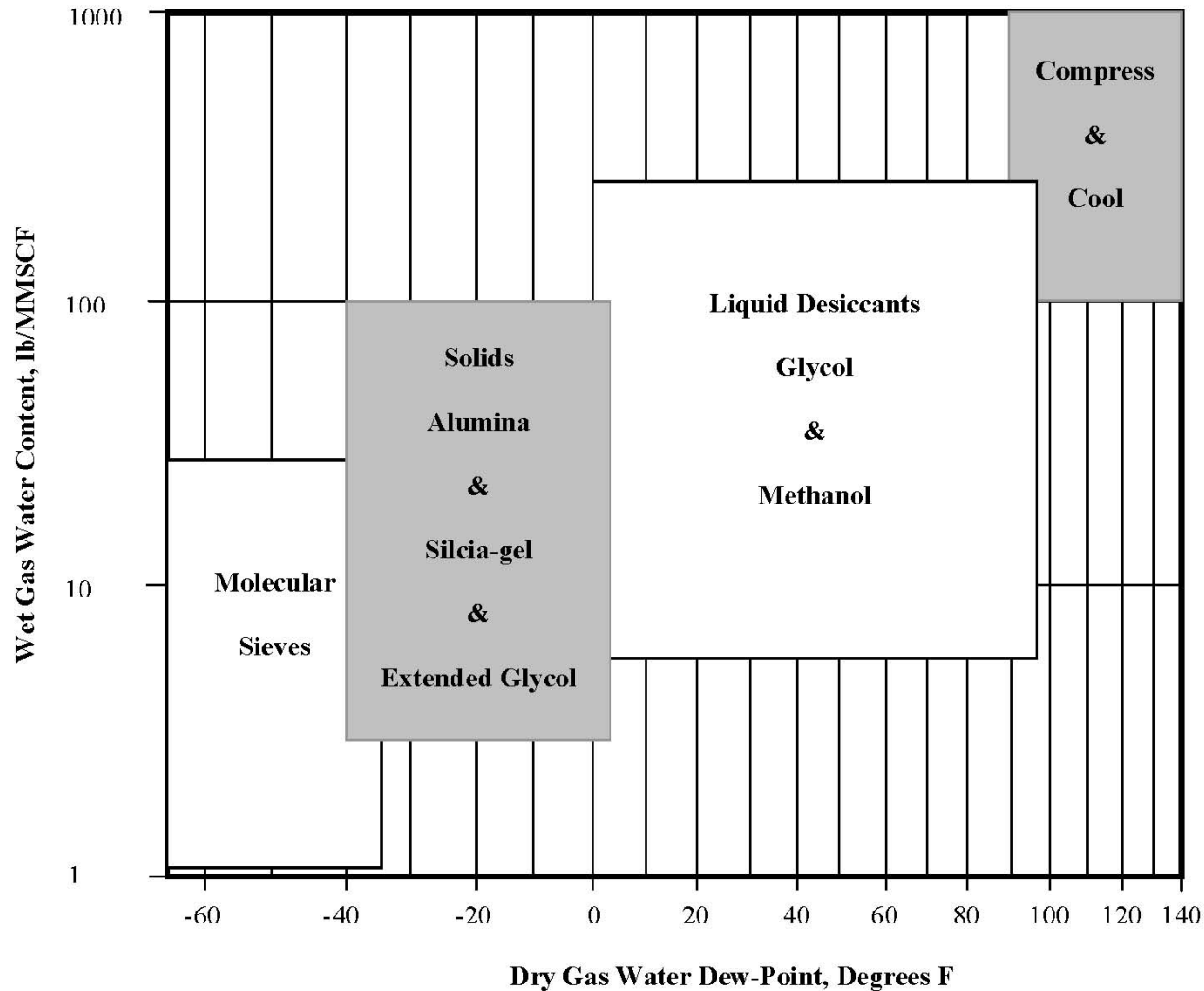
- ◆ **Absorption and refrigeration with hydrate inhibition** is the most common dehydration process used to meet **pipeline sales specifications**.
  - ❖ TEG is most common in absorption systems
  - ❖ MEG is most common in glycol injection systems
- ◆ **Adsorption processes are used to obtain very low water contents required in low temperature processes, for example LNG**

**Natural gas is commercially dehydrated in one of three ways;**

- 1. Absorption (Glycol dehydration)**
- 2. Adsorption (Molecular Sieve, Silica Gel, or Activated Alumina)**
- 3. Condensation (cooling) (Refrigeration with Glycol or Methanol injection)**

# Application Guideline MAP

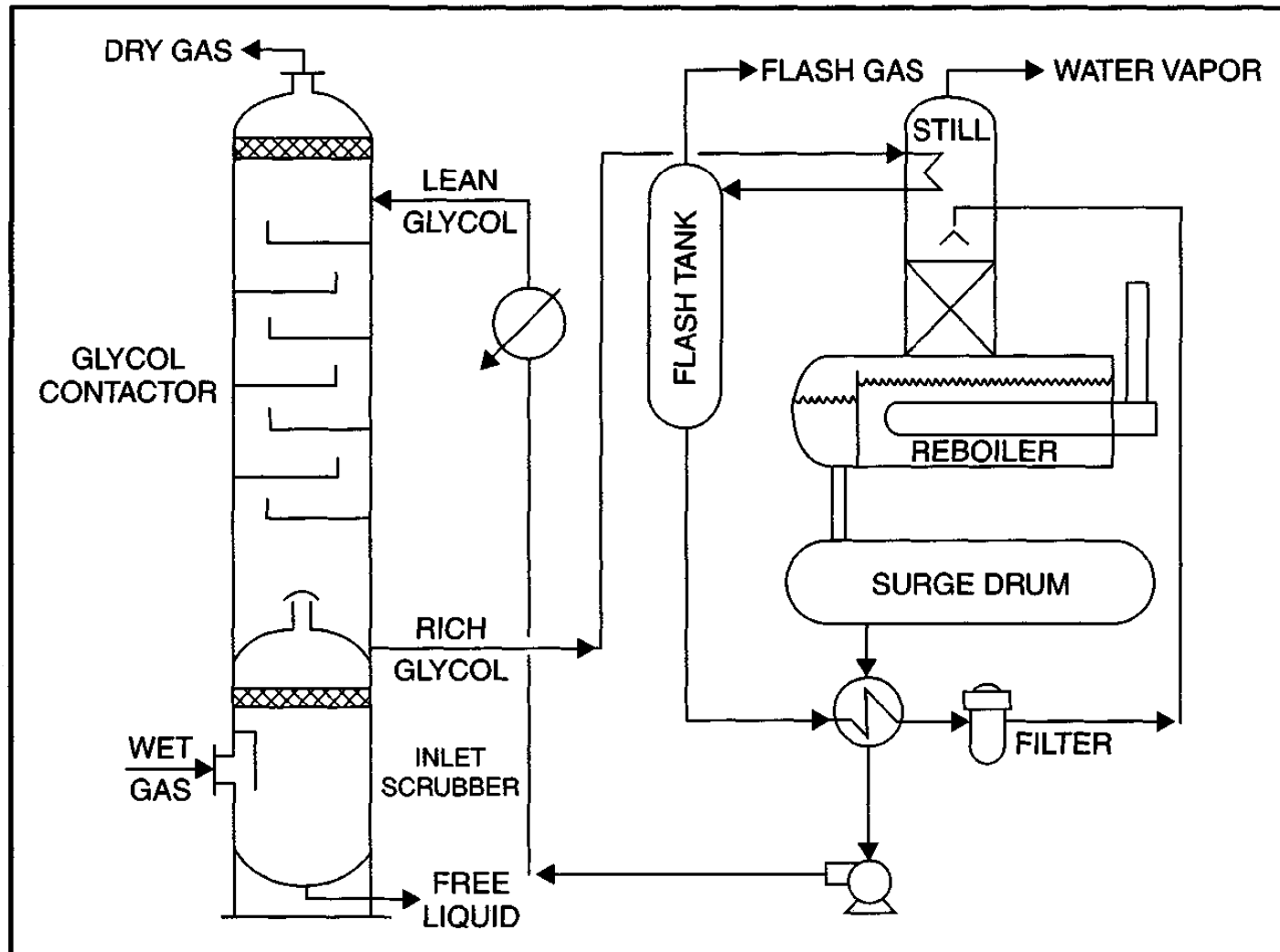
General process application selection is outlined on the map below. The axes are water content in the wet gas, in lb/MMSCF and dry gas dew point, in °F.



# Absorption Dehydration by Glycol

- ◆ Natural gas is dried by absorption, often in a **countercurrent scrubbing unit**.
- ◆ A liquid having **a strong affinity for water** is used as an absorbent.
- ◆ A **good absorbent** should have;
  1. Strong affinity for water
  2. Low cost
  3. Non corrosive
  4. Low affinity for hydrocarbons and acid gases
  5. Thermal stability
  6. Easy regeneration
  7. Low viscosity
  8. Low vapor pressure at the contact temperature
  9. Low tendency to foam
  
- ◆ **Four glycols are used for dehydration and/or inhibition;**
  1. Monoethylene Glycol (MEG) also called ethylene glycol (EG)
  2. Diethylene glycol (DEG)
  3. Triethylene glycol (TEG)
  4. Tetraethylene glycol (T<sub>4</sub>EG)

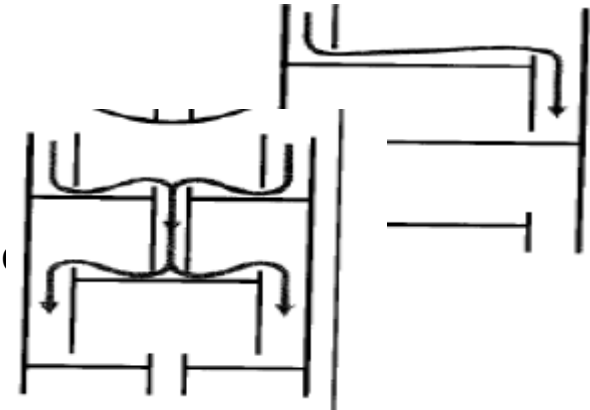
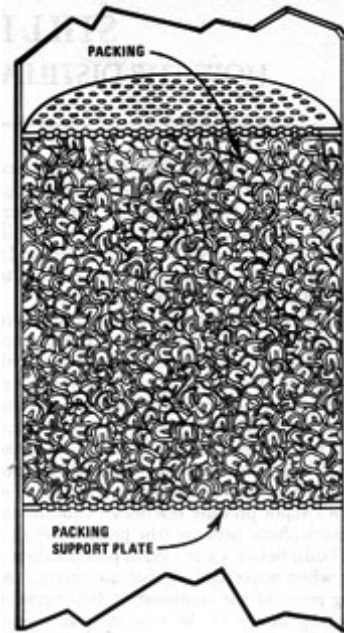
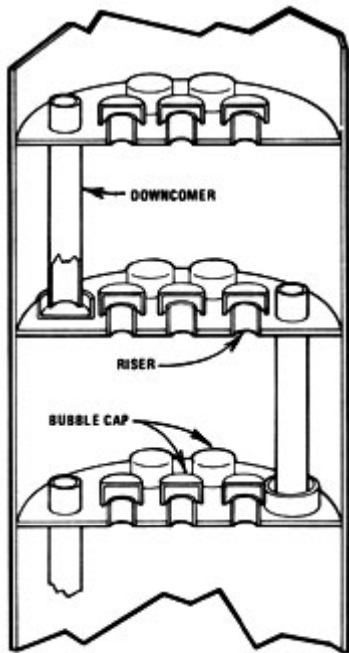
# Basic glycol dehydration unit



*Simplified flow diagram for a glycol dehydration unit. from the GPSA Engineering Data Book, 12<sup>th</sup> ed.*

## The glycol dehydration unit

Wet gas (no liquid water) enter bottom of absorber and flows countercurrent to the glycol. Lean glycol enters at the top



- Absorber inlet
  - Tray
  - Bubble cap
  - Valve
  - Sieve
  - Packing
  - Berl Saddle, Raschig Ring.....
- Reactor  
 One, two pass trays  
 Bubble Cap  
 Berl Saddle  
 Valve tray  
 Sieve tray  
 Bubble Cap tray

# Glycol Absorption Unit

## Pros

- ❖ Low initial cost
- ❖ Low pressure drop across absorption towers
- ❖ Recharging of towers present no problems
- ❖ Materials that would cause fouling of some solid adsorbents can be tolerated in the contactor

## Cons

- ❖ Suspended matter, such as dirt, scale, and iron oxide may contaminate glycol solutions
- ❖ Overheating of solutions may produce both low and high boiling decomposition products
- ❖ The resultant sludge may collect on heating surfaces, causing some loss in efficiency, or, in severe cases, complete flow stoppage
- ❖ When both oxygen and hydrogen sulfide is present, corrosion may become a problem because of the formation of acid material in the glycol solution
- ❖ Liquids such as water, light hydrocarbons or lubrication oils in inlet gas may require installation of an efficient separator ahead of the absorber. Highly mineralized water entering the system with inlet gas may, over long periods crystallize and fill the re-boiler with solid salts
- ❖ Foaming of solution may occur with a resultant carry-over of liquid. The addition of a small quantity of antifoam compound usually remedies this problem

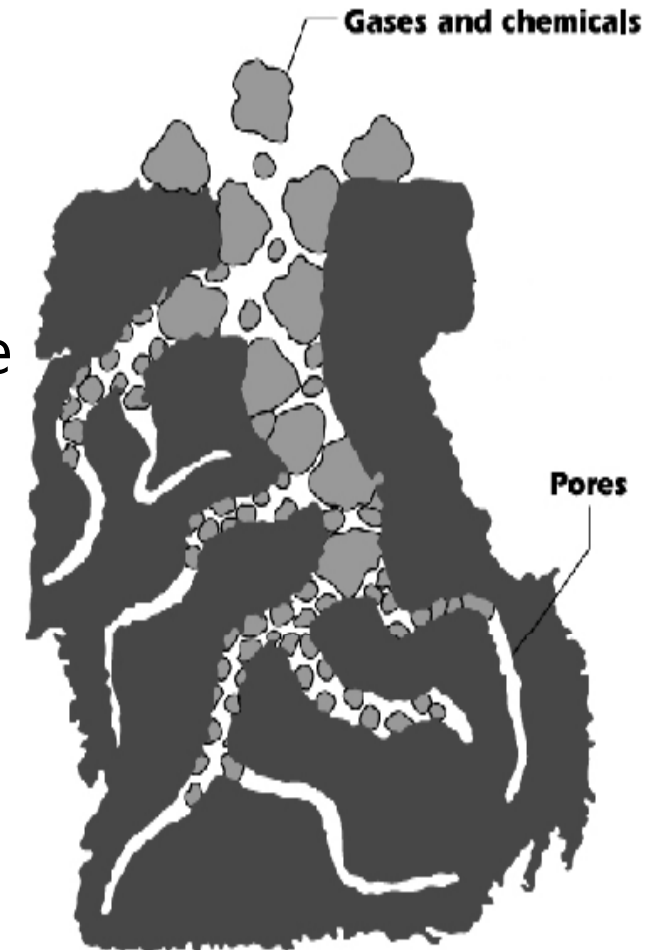
# Dehydration by Adsorption

- ◆ Adsorption describes any process where gas molecules are held on the surface of a solid by surface forces.
- ◆ Adsorbents may be divided into two classes.
  - ❖ Species is adsorbed due to physisorption and capillary condensation
  - ❖ Species is adsorbed due to chemisorption (not much used in natural gas processing)
- ◆ A sorbent must have the following properties;
  1. High adsorption capacity at equilibrium
  2. A microporous structure which affords a very large specific surface.
  3. Easily and economically regenerated
  4. Fast adsorption kinetics
  5. Low pressure drop
  6. High cyclic stability (kinetic and capacity)
  7. No significant volume change (swelling shrinking)



# Adsorption of water by a solid desiccant

- ◆ **Adsorption** is purely a surface phenomenon
- ◆ molecules from the gas are held on the surface of a solid by surface force
- ◆ function of operating temperature ( $\downarrow$  as  $T \uparrow$ ) and pressure ( $\uparrow$  as  $P \uparrow$ )
- ◆ In NG industry a solid desiccant is used to remove water vapor from a gas stream





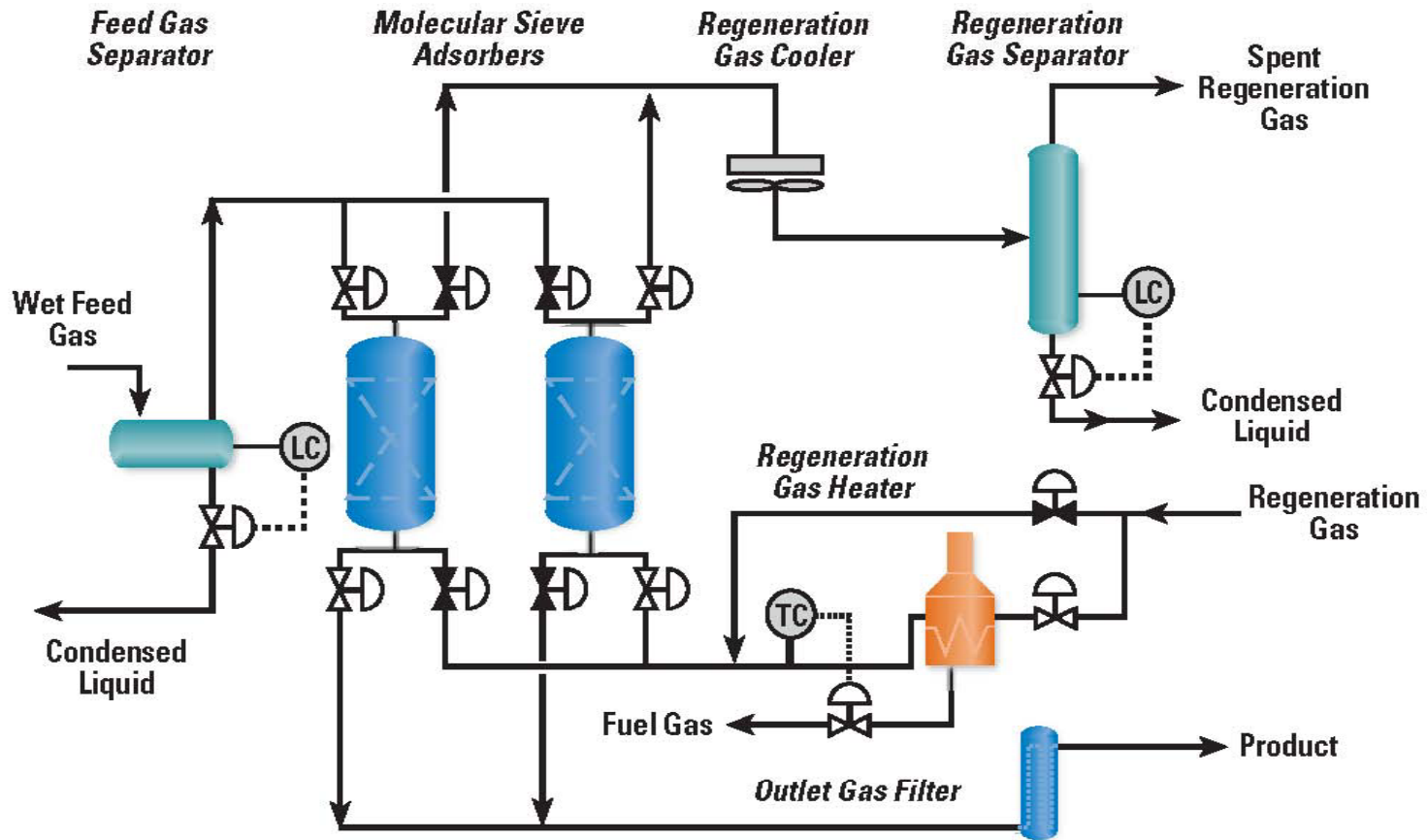
## The commercial available sorbents can be divided into three broad categories:

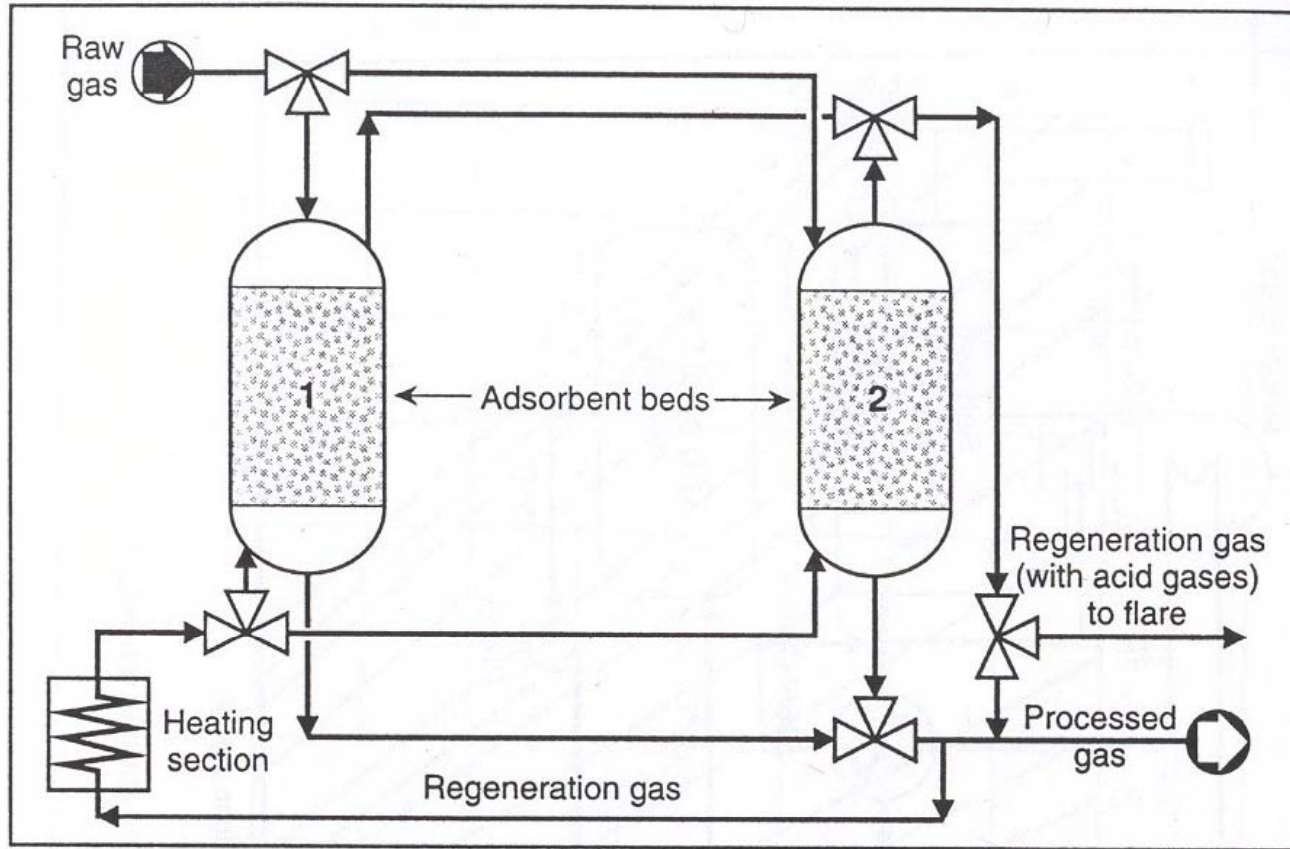
- ◆ **Silica gel (Gel type)** : A granular amorphous solid (silica gel ( $\text{SiO}_2$ ))
  - ❖ Outlet gas water content down to 10 ppm (v/v) and dew point  $-60\text{ }^\circ\text{C}$  can be achieved.
  - ❖ Regenerated between 120 and 200  $^\circ\text{C}$ .
  - ❖ It adsorbs hydrocarbons, which are desorbed during regeneration.
  - ❖ Silica gel is destroyed by free water which causes the granules to burst, and react with bases.
  
- ◆ **Activated alumina  $\text{Al}_2\text{O}_3$**  : Hydrated form of aluminum oxide  $\text{Al}_2\text{O}_3$ , activated by drying off part of the hydrated water adsorbed on the surface.
  - ❖ Outlet gas water content  $<1$  ppm (v/v), outlet dew point  $-73\text{ }^\circ\text{C}$  can be achieved.
  - ❖ Heavy hydrocarbons are adsorbed but can not be desorbed during regeneration.
  
- ◆ **Molecular sieves (Zeolites)** : Alkali metal crystalline aluminosilicates, very similar to natural clays.
  - ❖ Outlet gas water content down to 0.03 ppm (v/v) , outlet dew point  $-100\text{ }^\circ\text{C}$ .
  - ❖ Water is adsorbed in a micro porous structure.
  - ❖ The presence of carbonyl sulfide (COS) and carbon disulfide ( $\text{CS}_2$ ) should be avoided.
  - ❖ The adsorbent must be replaced frequently (about every three year).
  - ❖ The water content in the feed must be low.

## Typical types of adsorbents

	<u>description</u>	<u>cost</u>	<u>water content depression</u>	<u>regeneration</u>	<u>adsorption of heavy hydrocarbons / regeneration</u>	<u>advantages</u>	<u>disadvantages</u>
<b><u>Alumina</u></b>	form of aluminum oxide (Al <sub>2</sub> O <sub>3</sub> )	least expensive	5 ppm	requires more heat for regeneration	yes / hard	excellent dew point depression	alkaline, cannot be used in the presence of acid gases
<b><u>Silica Gel and Silica-Alumina Gel</u></b>	manufactured from sulfuric acid and sodium silicate, combination of silica and alumina gels	medium	10 ppm	easy	yes / easy	handle sour gases	Sulfur can deposit, can't handle caustic or ammonia.
<b><u>Molecular Sieves</u></b>	crystalline form of alkali metal (calcium or sodium)	most expensive	1 ppm	requires more heat for regeneration	no / -	don't adsorb heavy hydrocarbons, best choice for sour gases, highly porous and very high surface area	expensive

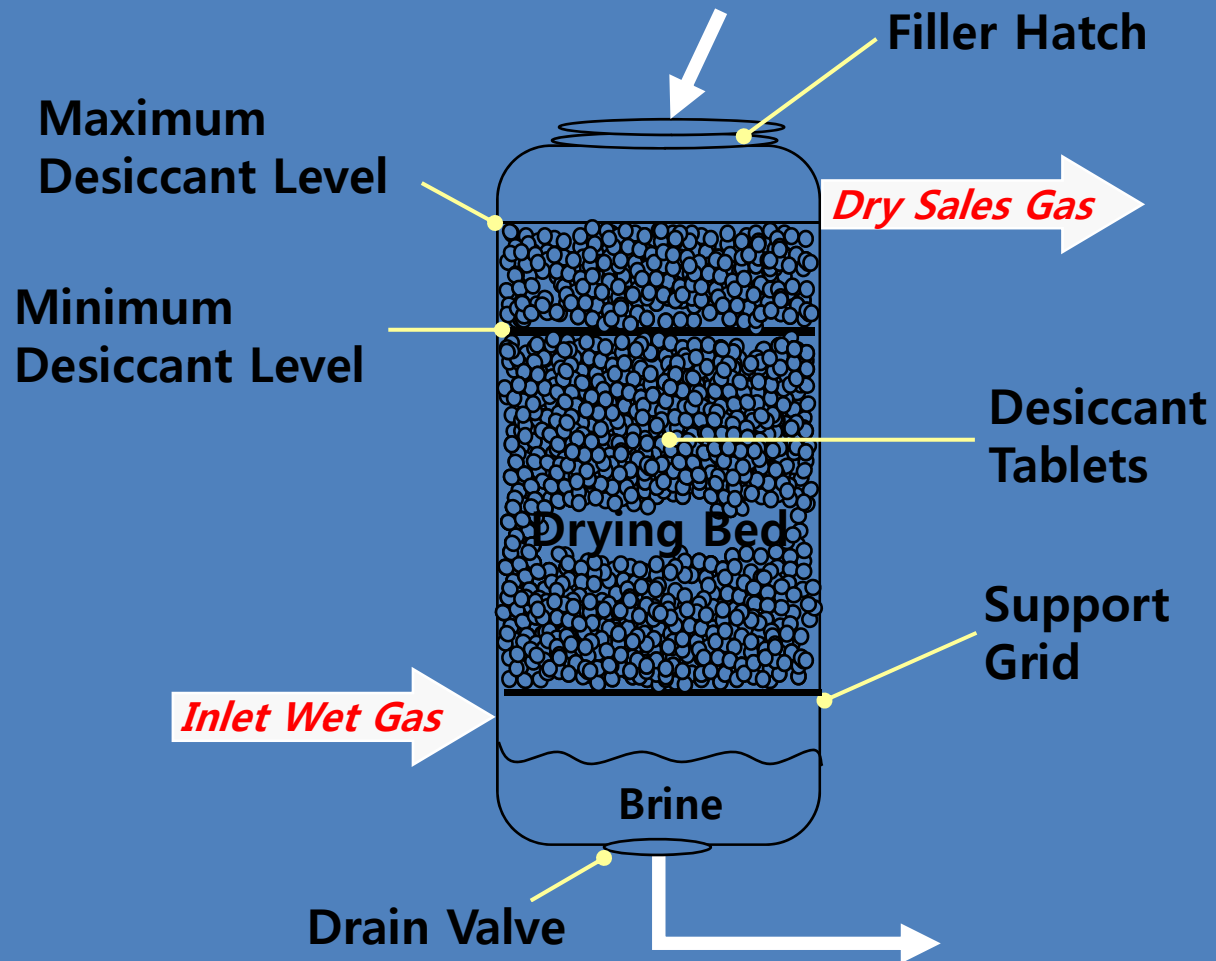
## An Open Cycle Molecular Sieve Dehydration System





**Flow sheet of a basic two tower adsorption system with regeneration**

# Desiccant Dehydrator Schematic



# Dehydration by Adsorption

## ◆ Advantages of Molecular Sieves:

- ❖ Very low dew point and water content can be obtained
- ❖ Best suited for large volumes of gas under very high pressure
- ❖ Dehydration of very small quantities of natural gas at low cost
- ❖ Insensitive to moderate changes in gas temperature, flow rate, and pressure.
- ❖ They are relatively free from problems of corrosion, foaming, etc.
- ❖ Some types can be used for simultaneous dehydration and sweetening

## ◆ Disadvantages of Molecular Sieves

- ❖ The most expensive adsorbents
- ❖ The regeneration temperature is very high (operating cost).
- ❖ Pressure drop is too high
- ❖ High space and weight required
- ❖ Mechanical breaking and contamination of liquid, oil and glycol are possible

# Dehydration by cooling(Refrigeration system)

A refrigeration system lowers the temperature of a fluid or gas below that possible when using air or water at ambient conditions.

## ◆ Refrigeration systems are used for

- ❖ Removing of water
- ❖ Chilling natural gas for NGL extraction
- ❖ Chilling natural gas for hydrocarbon dew-point control
- ❖ LPG product storage
- ❖ Natural gas liquefaction (LNG)

## ◆ Refrigeration processes:

### ❖ Mechanical refrigeration

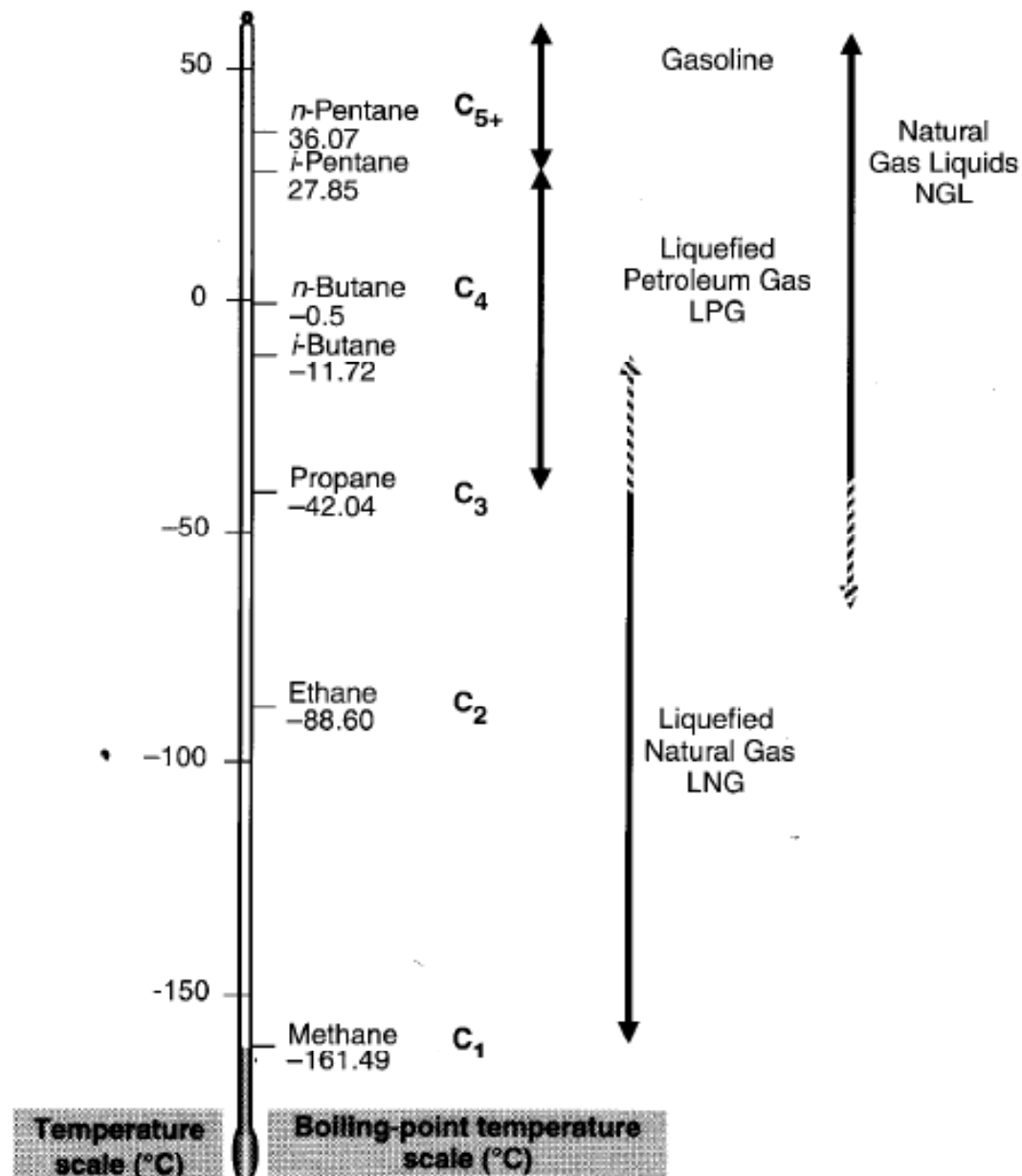
#### ● Compression (uses energy in form of work to pump heat)

- Absorption (use energy in form of heat to pump heat, ammonia systems)

### ❖ Expansion refrigeration

- Valve expansion (Joule Thompson)
- Turbine expansion (Turbo expander)

## Natural gas liquid fractions as a function of temperature at atmospheric pressure





# Compression refrigeration

Compression refrigerating is the most common mechanical refrigeration process. It has a wide range of applications in the gas process industry:

- ❖ Drying of natural gas
- ❖ Chilling natural gas for NGL extraction
- ❖ Chilling natural gas for hydrocarbon dewpoint control
- ❖ Chilling the LPG product storage
- ❖ Natural gas liquefaction

## Refrigerant

- ◆ The ideal refrigerant:
  - ❖ Is nontoxic, noncorrosive
  - ❖ Has physical properties compatible with system needs  
(vaporize and condense at system achievable temperatures and pressures)
- ◆ High latent heat of vaporization
  - ❖ Chiller temperatures  $> -40$  C propane, ammonia or R-22 are typical choices
  - ❖ At cryogenic conditions, ethylene, nitrogen and methane might be used
- ◆ Typical operating problems:
  - ❖ Loss of refrigerant
  - ❖ Contamination of refrigerant (change of properties)
  - ❖ Fouling on heat transfer surfaces