**9.5 Natural Gas Dehydration**

Water removal from gas stream is required because water in this case considers as impurity and presence water in the liquid phase causes corrosion or erosion problems in pipelines and equipment, especially when CO2 and H2S are present in the gas.

**9.5.1 Absorption (Glycol Dehydration Process)**

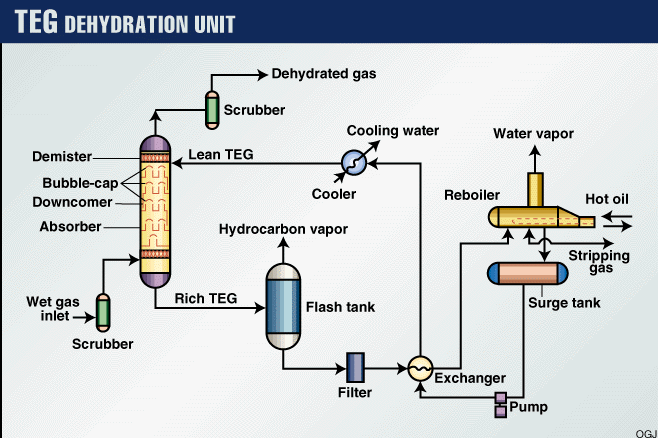
Absorption is defined as the transfer of a component from the gas phase to the liquid phaseand it is more favorable at a lower temperature and higher pressure. This result is concluded by considering the following relationship (which is a combination of Raoult’s law and Dalton’s law):

Where ***Pi*** is the pressure of pure component ***i***, P is the total pressure of the gas mixture (system), ***Xi*** is the mole fraction of component i in the liquid phase, ***Yi*** is the mole fraction of component I in the vapor phase, and ***Ki*** is the equilibrium constant, increasing with temperature and decreasing with pressure.

The basic principles of relevance to the absorption process are as follow:

1. In this process, a hygroscopic liquid is used to contact the wet gas to remove water vapor from it. Triethylene glycol (TEG) is the most common solvent used.

2. The actual absorption process of water vapor from the gas phase using glycol is dynamic and continuous. Therefore, the gas flow cannot be stopped to let a vapor and the liquid reach an equilibrium condition. Accordingly the system under consideration must be designed to allow for a close approach to equilibrium while the flow continues.



Flow diagram of TEG dehydration process

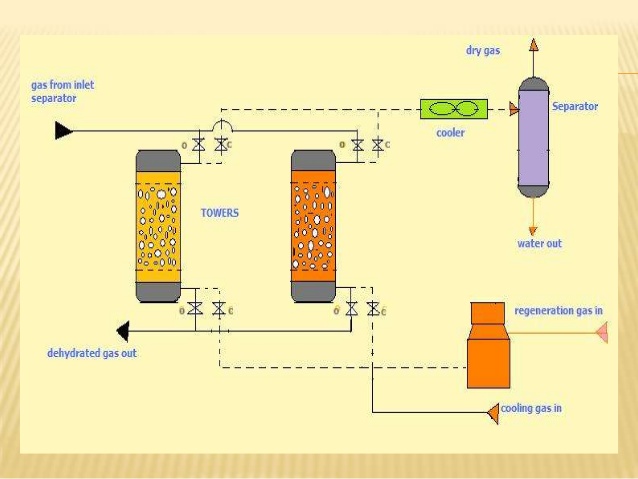
**9.5.2. Adsorption: Solid-Bed Dehydration**

Adsorption is the [adhesion](https://en.wikipedia.org/wiki/Adhesion) of [atoms](https://en.wikipedia.org/wiki/Atom), [ions](https://en.wikipedia.org/wiki/Ion), or [molecules](https://en.wikipedia.org/wiki/Molecule) from a gas, liquid, or dissolved solid to a [surface](https://en.wikipedia.org/wiki/Surface_science). This process creates a film of the adsorbate on the surface of the adsorbent.

The most important property is the capacity of the adsorbent, which determines the loading design expressed as the percentage of water to be adsorbed by the bed. The capacity decreases as temperature increases.

This method used when very low dew. It is based on fixed-bed adsorption of water vapor by a selected adsorbent. A number of solid desiccants (dryers) could be used such as silica gel, activated alumina, or molecular sieves.

The system may consist of two-bed, three-bed, or multi-bed operation. In the three-bed operation, if two beds are loading at different stages, the third one would be regenerated. The feed gas entering the bed from the top and the upper zone becomes saturated first. The second zone is the mass transfer zone (MTZ) and is being loaded. The third zone is still not used and active.



Solid-bed dehydration process

**9.6 Natural Gas Sweetening**

Gas sweetening process is used to remove the contamination gases presence in natural gas stream, the purposes of these processes so as that the gas is marketable and suitable for transportation.

Hydrogen sulfide H2S, carbon dioxide CO2, mercaptans (R–SH), are common contaminants found in natural gas streams. The removal of H2S from natural gas is accompanied by the removal of CO2 and carbonyl sulfide (COS) if present, since these have similar acid characteristics. Desulfurization processes are primarily of two types:

• Absorption into a liquid (wet process)

• Adsorption on a solid (dry process)

Both the absorption and adsorption processes may be of the physical or chemical type. The dominant sulfur removal steps are:

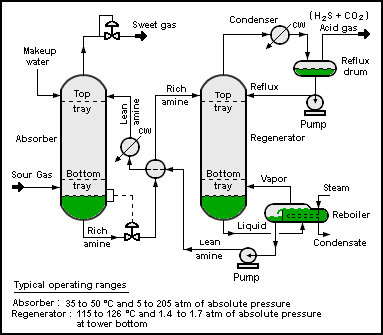
1. Amine absorbing (Girbotol process)

2. Claus process.

3. SCOT process-type tail gas treating.

**9.6.1. Amine Absorbing (Girbotol process)**

The monoethanolamine process, removes acid gases (H2S, CO2) from liquid hydrocarbons as well as from natural and from refinery gases. The Girbotol process uses an aqueous solution of monoethanolamine (H2NCH2CH2OH) that absorb H2S at low temperatures and releases H2S at high temperature. The monoethanolamine solution fills a tower called an absorber through which the sour gas is bubbled. Purified gas leaves the top of the tower, and the monoethanolamine solution leaves the bottom of the tower with the absorbed acid gases



Process flow diagram of a typical amine treating process

The monoethanolamine solution enters a regenerator tower where heat drives the acid gases from the solution. Monoethanolamine solution, restored to its original condition, leaves the bottom of the regenerator tower to go to the top of the absorber tower, and acid gases are released from the top of the regenerator.

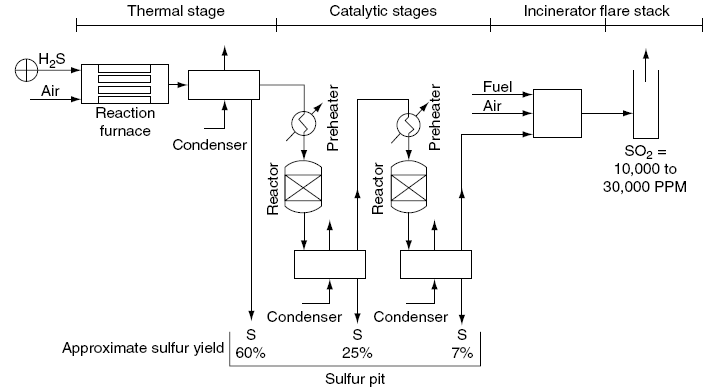
**9.6.2. Claus process**

The Claus process removes acid gas (H2S) involves combustion at 1000-1400°C of approximately 1/3 of hydrogen sulfide H2S to sulfur dioxide SO2 and then reaction of SO2 with the remaining H2S (200-350°C > dew point of S) in the presence of a fixed bed of activated alumina, cobalt molybdenum catalyst resulting in the formation of elemental sulfur (S):

***2H2S + 3O2→ 2SO2 + 2H2O***

***2H2S + SO2 → 3S + 2H2O***

In a once-through configuration, the acid gas stream is partially combusted by only providing sufficient oxygen in the combustion chamber to combust one- third of the acid gas. Two or three conversion reactors may be required depending on the level of H2S conversion required. Each additional stage provides incrementally less conversion than the previous stage. Overall, conversion of 96% to 97% of H2S to elemental sulfur is achievable in the Claus process.



The Claus process

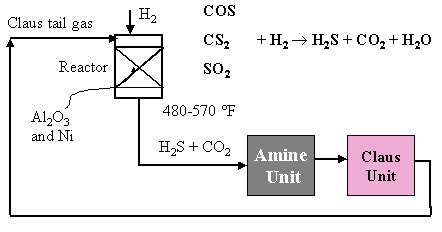
**9.6.3. The SCOT process**

If the conversion of Claus process is insufficient to meet air quality regulations, SCOT process is utilized to remove essentially the remaining H2S, together with other trace sulfur compounds, COS and CS2, formed in the burner side reaction in the tail gas from the Claus process.

The Claus tail gas is heated to about 298°C and reacted with H2 over a cobalt or molybdenum on alumina catalyst. The entire COS, CS2, S and SO2 in the Claus unit off gas are converted to H2S by the following reaction:

***COS, CS2 and SO2 + H2 → H2S + CO2 + H2O***

These reactions are highly exothermic. The hot gas from the reactor is cooled in a west heat boiler and finally quenched in a water cooling tower. The final stage involves the selective absorption of H2S in an amine solution. The vent gas from the SCOT absorber typically contains 200–500 ppm of H2S. This vent is normally incinerated before discharging to the atmosphere. The rich amine is stripped in a conventional manner, and the H2S rich stream is recycled back to the front of the Claus plant. The Claus plus SCOT processes combine to remove 99.5% of the S.



SCOT process