Institute of Natural Resources
Department of Fuel Engineering and Chemical Cybernetics

Natural gas processing

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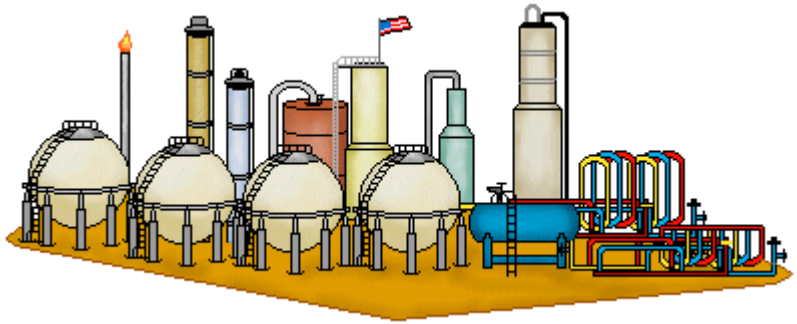
• Plan

- Fundamentals of natural gas processing
- Types of natural gas
- Products of natural gas processing
- Acid gas removal
- Sulfur Unit
- NGL recovery and treatment



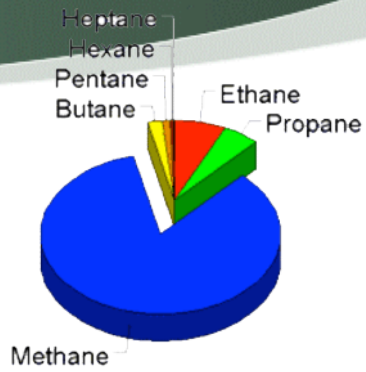
Fundamentals of natural gas processing

Gas plants include additional equipment for further gas processing to remove unwanted components such as **hydrogen sulfide** and **carbon dioxide**.

Acid gases

Sweetening/acid removal is the process of removing them

Types of natural gas



Types of natural gas depending on the composition:

✓ **Wet gas** is raw gas with a methane content of less than 85%.

✓ **Dry gas** is raw or treated natural gas that contains less than 15 liters of condensate per 1000 sm^3 (0.1 gallon per 1000 scf).

✓ **Sour gas** is raw gas with a content of more than 5.7 mg H_2S per scm (0.25 grains per 100 scf).

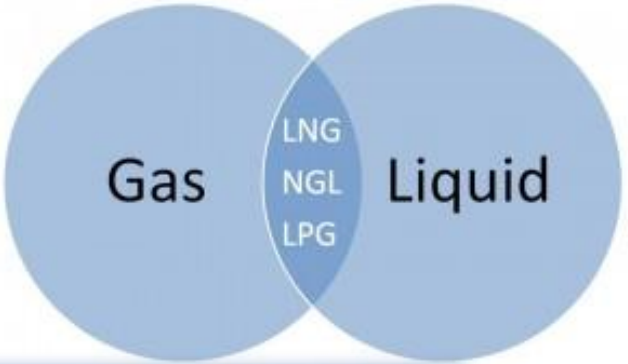
✓ **Acid gas** has a high content of acidic gases such as CO_2 or H_2S. Pipeline natural gas specification is typically less than 2% CO_2.

✓ **Condensates** are a mixture of hydrocarbons and other components. These are normally gaseous from the well but condense out as liquid during the production process.

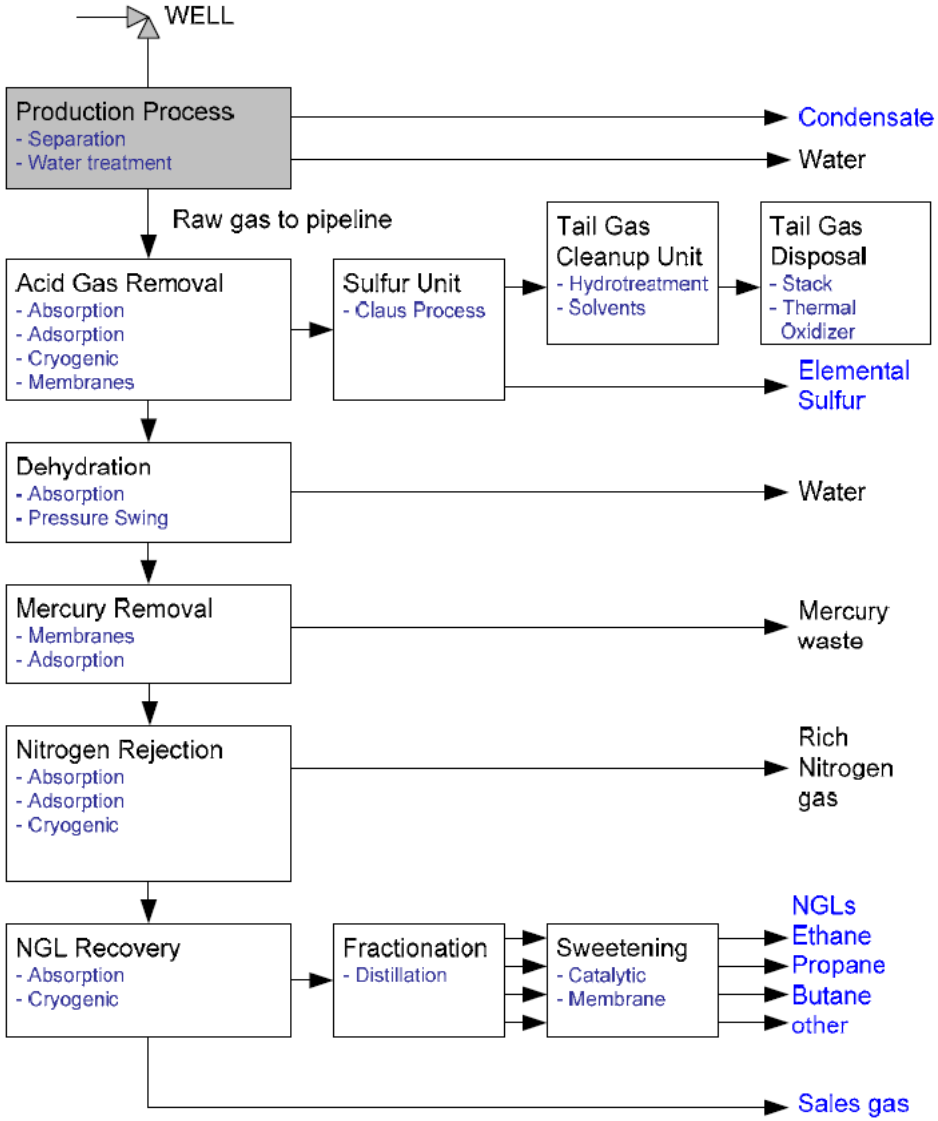
Products of natural gas processing

Raw gas is processed into various products or fractions:

- ✓ **Natural gas**.
- ✓ **Natural gas liquids (NGL)** is a processed purified product consisting of ethane, propane, butane or some higher alkanes separately, or in a blend.
  It is a raw material for petrochemical industry.
- ✓ **Liquefied petroleum gas (LPG)**.
- ✓ **Liquefied natural gas (LNG)**.
- ✓ **Compressed natural gas (CNG)**.



Natural gas processing



Raw natural gas must be processed to meet the trading specifications of pipeline and gas distribution companies

Figure 1. Typical gas plant

• Acid gas removal

Acid gases such as **CO_2** and **H_2S form acids** when reacting with water, and **must be removed** to prevent corrosive damage to equipment and pipelines.

H_2S is also toxic and total sulfur content is normally regulated.

• Absorption

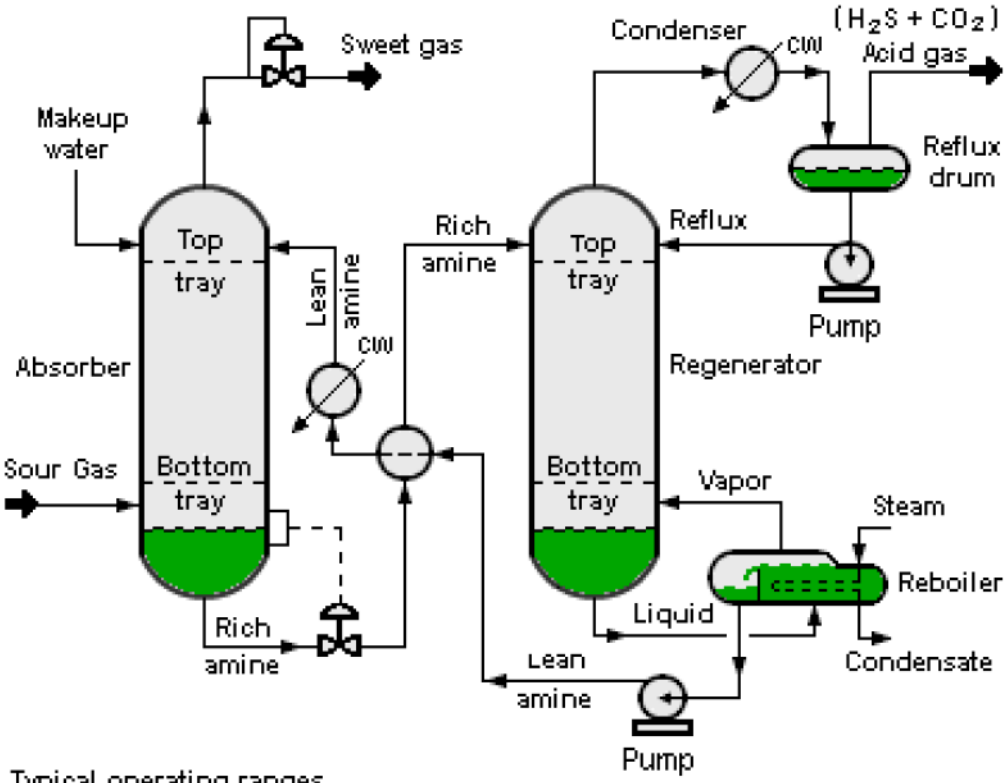
allows acidic gases to be dissolved in a solvent, to be released by regeneration in a later stage.

- ✓ **Amine absorption** dominates for acid gas removal.
- ✓ **Monoethanolamine (MEA)** dominates for CO_2 removal.

• Absorption

A typical amine gas treating process consists of:

- ✓ **absorber unit,**
- ✓ **regenerator unit,**
- ✓ **accessory equipment.**

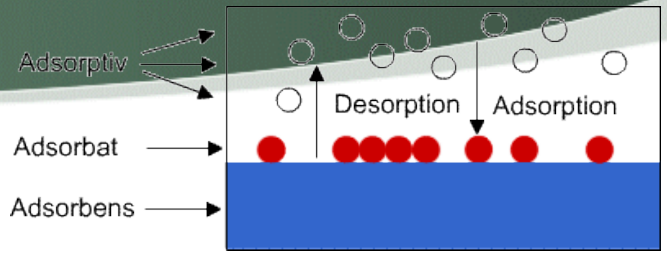


Typical operating ranges

Absorber : 35 to 50 °C and 5 to 205 atm of absolute pressure
Regenerator : 115 to 126 °C and 1.4 to 1.7 atm of absolute pressure at tower bottom

In the **absorber**, a **"lean" amine solution absorbs H_2S and CO_2** from the upflowing sour gas to produce a sweetened gas stream as a product.

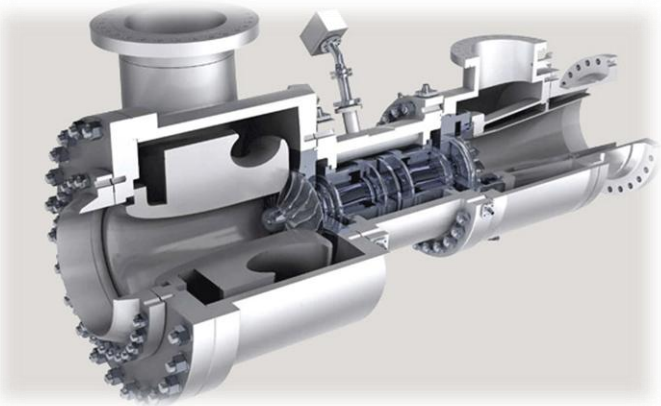
The **"rich" amine solution** contains the absorbed acid gases and is **routed into the regenerator**.



• Adsorption

relies on the molecules to bind to the surface of certain solids.

- ✓ **pressure swing adsorption (PSA),**
- ✓ **temperature swing adsorption (TSA),**
- ✓ **electric swing adsorption (ESA).**



• Cryogenic removal

uses a turbo expander:

a gas turbine is driven by the expanding gas which then cools to below the dew point for the gas to be removed.

Is used when the content of CO_2 is high – around 50%.

- **Membrane based removal**

is based on certain materials that allow the acid gases, but not the hydrocarbons, to diffuse through the membrane.

- **Sulfur Unit**

the H_2S-rich stripped gas is then fed to a **Claus process**

Thermal section

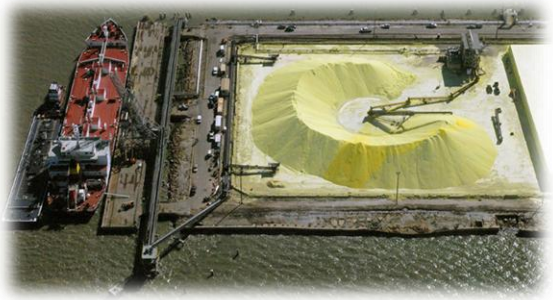
fires H_2S with air or oxygen to produce SO_2 and elemental sulfur

Catalytic section

allows more H_2S to react with SO_2 with TiO_2 to produce water and elemental sulfur

The Claus reaction:

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$



• Tail gas treatment

Tail gas treatment unit serves to **reduce the sulfur content to below 250 ppm.**

Shell Claus off gas treatment (SCOT) process removes SO_2 by combustion with hydrogen over catalysts to produce H_2S and water.

• Dehydration

Dehydration is either glycol-based scrubbers or based on pressure swing adsorption (PSA).

• Mercury removal

is generally based on **molecular sieves**

A substance containing a material with tiny pores to achieve a large surface area *(activated carbon)*

The surface of the material allows certain molecules to bind by surface tension.

The molecules can later be extracted and the sieve material regenerated by:

- ✓ **heating,**
- ✓ **pressure,**
- ✓ **purging with a carrier gas.**

Nitrogen rejection

Higher concentrations of nitrogen are removed by

Absorption with lean oil or another special solvent

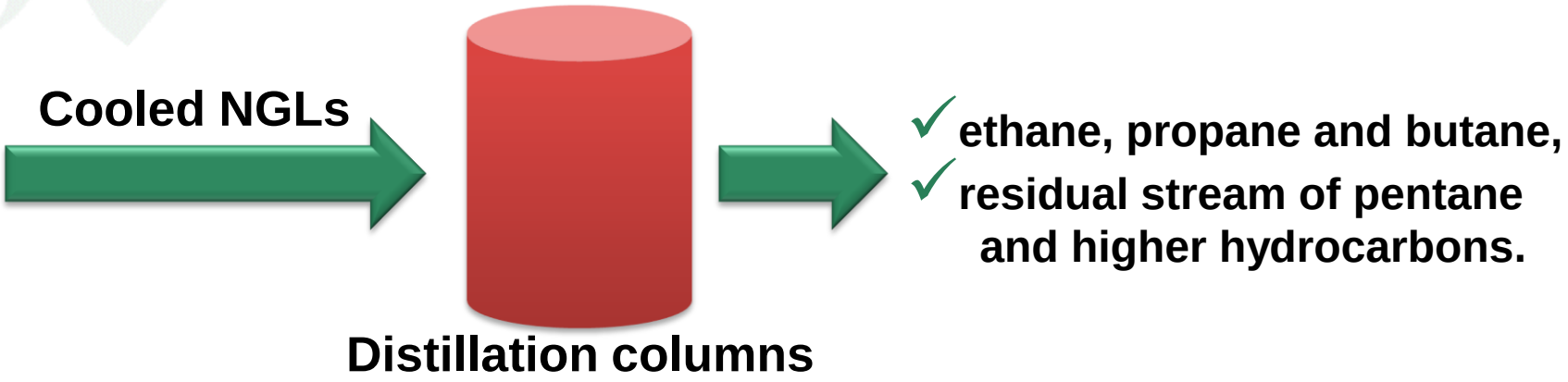
Excessive nitrogen is removed by

Cryogenic distillation

permits production of helium

• NGL recovery and treatment

Remaining NGLs are recovered from the gas stream by a **cryogenic turbo expander-based process** followed by a fractionating process.



• Mercaptans removal

Sweetening process based on **molecular sieves adsorption or catalytic oxidization**.