

## Lecture (11)

### Transportation

Gas, as a result of the storage difficulties, needs to be transported immediately to its destination after production from a reservoir. There are a number of options for transporting natural gas energy from oil and gas fields to market. These include:

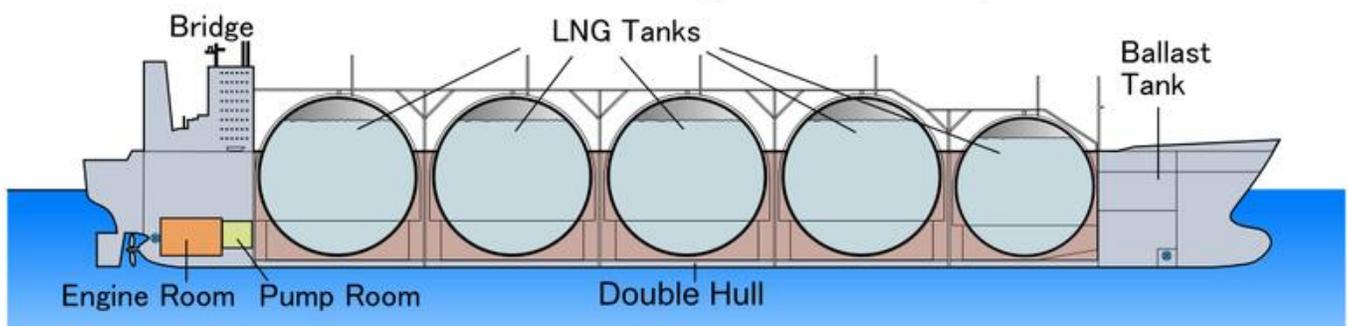
- Pipelines
- liquefied natural gas (LNG)
- compressed natural gas (CNG),
- gas to solids (GTS), i.e., hydrates,
- gas to power (GTP), i.e., electricity,
- gas to liquids (GTL), with a wide range of possible products, including clean fuels, plastic precursors, or methanol.

some of the most popular ways of transporting crude oil and gas across the world:

- 1) Trucks.
- 2) Pipelines.
- 3) Ocean.
- 4) Rail.



### LNG tanker (side view)



## **Natural gas Stored**

There are two methods for storing natural gas:

### 1) Underground gas storage

Natural gas is injected into the underground storages, and as more natural gas is added, more pressure is building up. It means that the underground facility becomes a sort of pressurized natural gas container.

More natural gas means more pressure, so the extraction is easier. If the natural gas level drops below a certain amount, there is no pressure, so the extraction is difficult. That is why there is a certain amount of gas that may never be extracted.

### 2) LNG (liquefied natural gas)

LNG can be shipped and stored in liquid form. It takes up much less space than gaseous natural gas. It is shipped mostly on the seas.

For LNG there are liquefied natural gas storage tanks with the ability to store gas at the very low temperature of  $-162\text{ }^{\circ}\text{C}$ .



## Natural Gas Processing

Natural-gas processing is a done with process designed to clean raw natural gas by separating impurities and various non-methane hydrocarbons and fluids to produce what is known as pipeline quality dry natural gas. Fig (8) is a schematic block flow diagram of a typical natural gas processing plant.

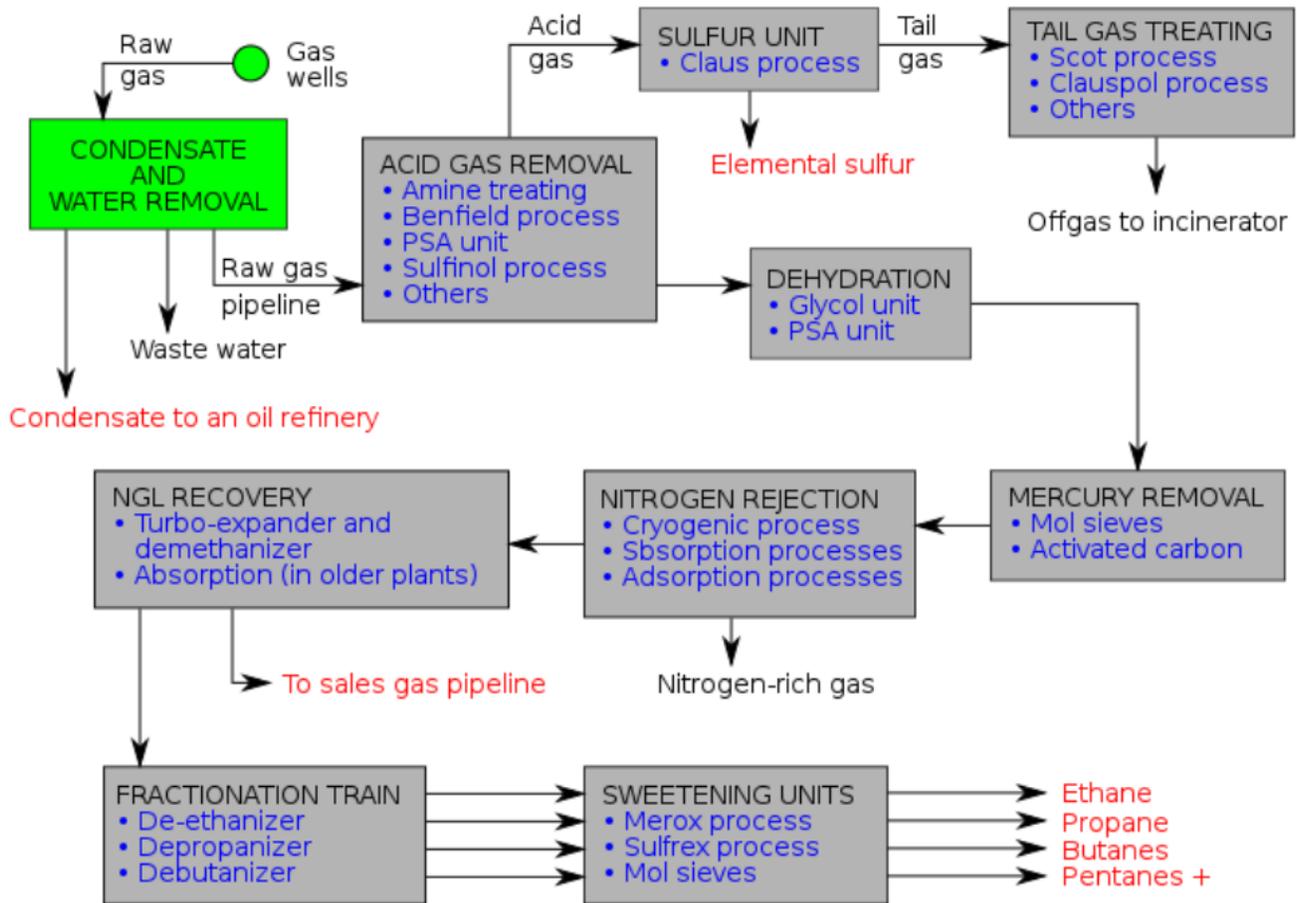


Fig. 8: Schematic flow diagram of a typical natural gas processing plant.

## 1. Phase Separation

Raw natural gas is commonly collected from a group of adjacent wells and is first processed at that collection point for removal of free liquid water and natural gas condensate.

Hydrocarbon condensate recovered from natural gas may be shipped without further processing but is typically stabilized to produce a safe transportable liquid. Unstabilized condensates contain a large percentage of methane and ethane, which will vaporize easily in storage tanks.

Stabilization is the full removal of light fractions from the condensate, usually achieved by distillation. Stabilized liquid will generally have a vapor pressure specification (Reid vapor pressure of  $<10$  psi), as the product will be injected into a pipeline or transport pressure vessel, which has definite pressure limitations.

## 2. Acid gas treating (Sweetening)

In addition to heavy hydrocarbons and water vapor, natural gas often contains other contaminants that may have to be removed completely or partially.

- Carbon dioxide ( $\text{CO}_2$ ),
- Hydrogen sulfide ( $\text{H}_2\text{S}$ ),
- Other sulfur-containing species such as mercaptans

These compounds are collectively known as “acid gases.”  $\text{H}_2\text{S}$  when combined with water forms a weak sulfuric acid, whereas  $\text{CO}_2$  and water form carbonic acid, thus the term “acid gas.” Natural gas with  $\text{H}_2\text{S}$  or other sulfur compounds present is called “sour gas,” whereas gas with only  $\text{CO}_2$  is called “sweet.”

Both  $\text{H}_2\text{S}$  and  $\text{CO}_2$  are very undesirable, as they cause corrosion and present a major safety risk.

### 3. Dehydration

Water dew point control is required to meet specifications and to control hydrate formation. Gas hydrate formation is a major concern for engineers in pipeline and natural gas transportation industries as it causes choking/plugging of pipelines and other related problems. Methods of preventing hydrate formation in the plant include:

- Lowering the hydrate formation temperature with chemical inhibition or
- Dehydration to remove the water.

### 4. Recovery and Separation of Natural Gas Liquids (NGLs)

- Hydrocarbon dew point or hydrocarbon liquid recovery involves cooling the gas and condensing out the liquids.
- The residue gas from the NGL recovery section is the final, purified sales gas which is pipelined to the end-user markets.
- The recovered NGL stream is processed through a fractionation train consisting of three distillation towers in series: a deethanizer, a depropanizer and a debutanizer.
- The overhead product from the deethanizer is ethane and the bottoms are fed to the depropanizer.
- The overhead product from the depropanizer is propane and the bottoms are fed to the debutanizer.
- The overhead product from the debutanizer is a mixture of normal and iso-butane, and the bottoms product is a C5+ mixture.
- The recovered streams of propane, butanes and C5+ are each "sweetened" in a Merox process unit to convert undesirable mercaptans into disulfides and, along with the recovered ethane, are the final NGL by-products from the gas processing plant

## Lecture (12)

### Separation

Natural gases produced from gas wells are normally complex mixtures of hundreds of different compounds. A typical gas well stream is a high-velocity, turbulent, constantly expanding mixture of gases and hydrocarbon liquids, intimately mixed with water vapor, free water, and sometimes solids. The well stream should be processed as soon as possible after bringing it to the surface.

*Field Processing of Natural Gas:*

- *Separating the gas from free liquids such as crude oil*
- *Processing the gas to remove condensable and recoverable hydrocarbon vapors*
- *Processing the gas to remove condensable water vapors*
- *Processing the gas to remove other undesirable compounds such as hydrogen sulfide or carbon dioxide.*

Most separators work based on the principles of gravity segregation and/or centrifugal segregation.

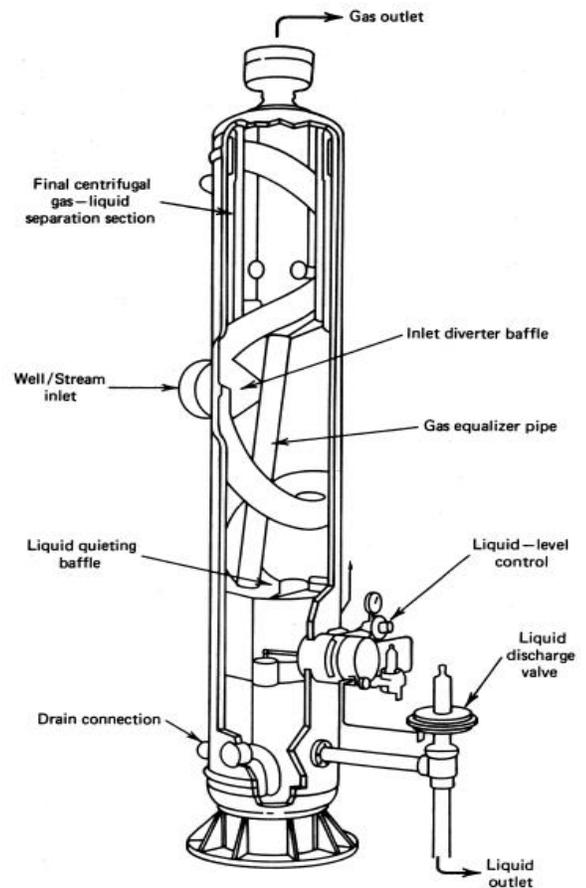
#### Types of Separators

- *Vertical Separator*
- *Horizontal Separator*
  - *Single tube*
  - *Double tube*
- *Spherical Separator*

Each type of separator has specific advantages and limitations. Selection of separator type is based on several factors including characteristics of production steam to be treated, floor space availability at the facility site, transportation, and cost.

## Vertical Separators

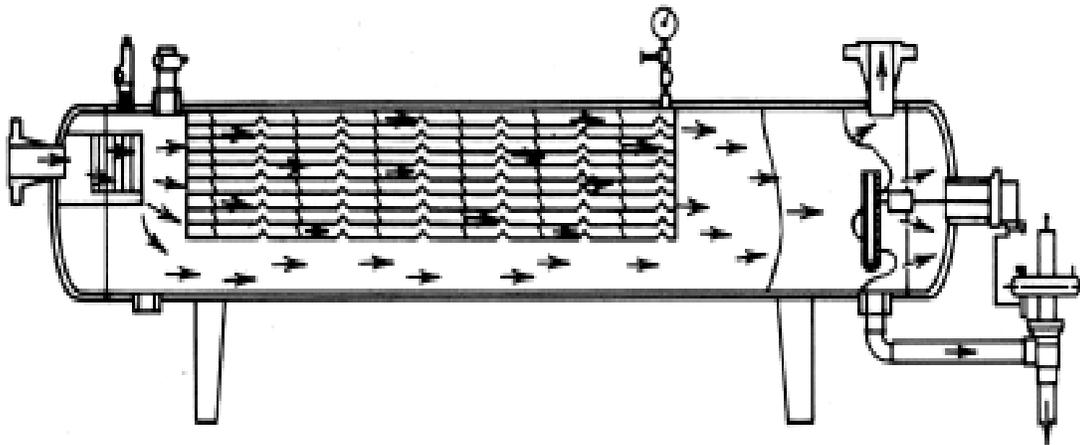
- Vertical separators are often used to treat low to intermediate gas/oil ratio well streams and streams with relatively large slugs of liquid.
- Vertical separators occupy less floor space, which is important for facility sites such as those on offshore platforms where space is limited.
- Owing to the large vertical distance between the liquid level and the gas outlet, the chance for liquid to revaporize into the gas phase is limited. However, due to the natural upward flow of gas in a vertical separator against the falling droplets of liquid, adequate separator diameter is required.
- Vertical separators are more costly to fabricate and ship in skid-mounted assemblies



## Horizontal Separators

- Separators are usually the first choice because of their low costs. Horizontal separators are widely used for high gas/oil ratio well streams, foaming well streams, or liquid-from-liquid separation.
- They have much greater gas/liquid interface due to a large, long, baffled gas separation section.

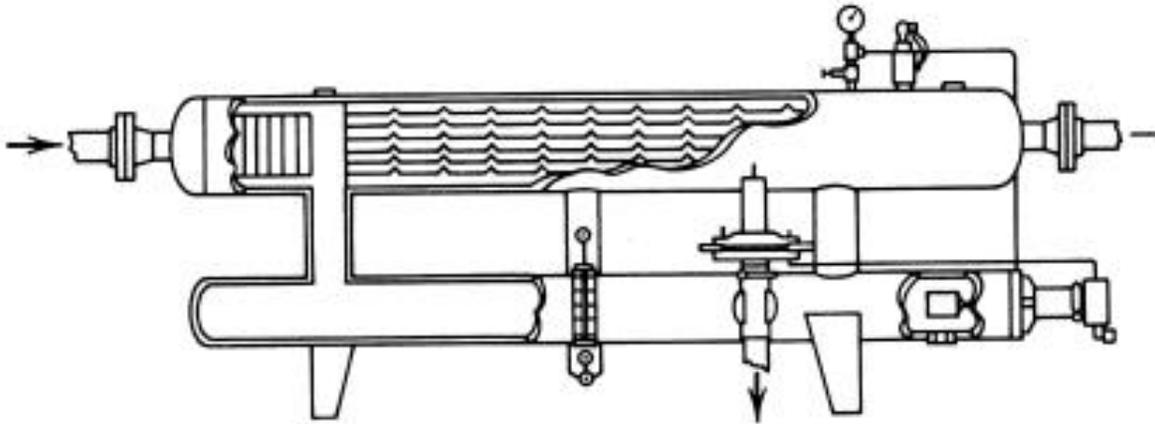
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### **horizontal double-tube separator**

A horizontal double-tube separator consists of two tube sections.

- The upper tube section is filled with baffles, and gas flows straight through and at higher velocities, and the incoming free liquid is immediately drained away from the upper tube section into the lower tube section. Horizontal double-tube separators have all the advantages of normal horizontal single-tube separators plus much higher liquid capacities.



### Spherical Separator

- Spherical separators offer an inexpensive and compact means of the separation arrangement.
- Owing to their compact configurations, this type of separator has a very limited surge space and liquid settling section.
- Also, the placement and action of the liquid-level control in this type of separator is more critical.

