Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum and Gas Refining Engineering

Gas Technology

Forth Class

Lectures 4

By

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Natural gas Formation

Natural gas exists in nature under pressure in rock reservoirs in the Earth's crust, either in conjunction with and dissolved in heavier hydrocarbons and water or by itself. It is produced from the reservoir similarly to or in conjunction with crude oil. Natural gas has been formed by the degradation of organic matter accumulated in the past millions of years. Two main mechanisms **(biogenic and thermogenic)** are responsible for this degradation

- **Biogenic gas** is formed at shallow depths and low temperatures by the anaerobic bacterial decomposition of sedimentary organic matter. Biogenic gas consists almost entirely of methane. **Methanogens** are microscopic organisms which live in environments devoid of oxygen and chemically decompose organic matter, creating methane as a byproduct.
- **Thermogenic gas** is formed at deeper depths by:

  (1) Thermal cracking of sedimentary organic matter into hydrocarbon liquids and gas

  (2) Thermal cracking of oil at high temperatures into gas.

  Thermogenic gas can also contain significant concentrations of ethane, propane, butanes, and heavier hydrocarbons.

Natural Gas Resources

The presence of gas in a mixture of hydrocarbons depends on their phase behavior, which in turn, depends greatly on

- The pressure and temperature of the mixture which both increase with depth
- The history of the reservoir.

It is generally true that the same organic matter could have evolved into

- **Coal**
- **Heavy oil with virtually no gas**, usually found at depth ≤ 3000ft
- **Light oil with lots of dissolved gas**, at depths > 3000ft, oil becomes lighter which means that gas coexist with oil.

Gas can be in the form of :

- A gas-cap on top of the oil zone.
- It can be dissolved in the oil.

As depth increases, more gas is present. Around 10,000 to 12,000 ft depth are some of the most prolific oil reservoirs in the world and almost all of them contain oil of API gravity between 28 and 32. They also coexist with substantial quantities of gas, which, when separated from oil at the surface, will evolve into 500 to 1,000 scf/stb (standard cubic feet per stock tank barrel).

Just gas: At depth of 17,000 ft and certainly over 20,000 ft, reservoirs contain almost exclusively natural gas. **[Terms used in the petroleum industry to describe natural gas reservoirs]**

Figure (1) shows a simplified flow of material from reservoir to finished product and provides an overall perspective of the steps involved in taking natural gas from the wellhead to the customer. Some gas plants receive feeds from refineries. These streams differ from natural gases in that they can contain propylene and butylene. They may also contain trace amounts of undesirable nitrogen compounds and fluorides.

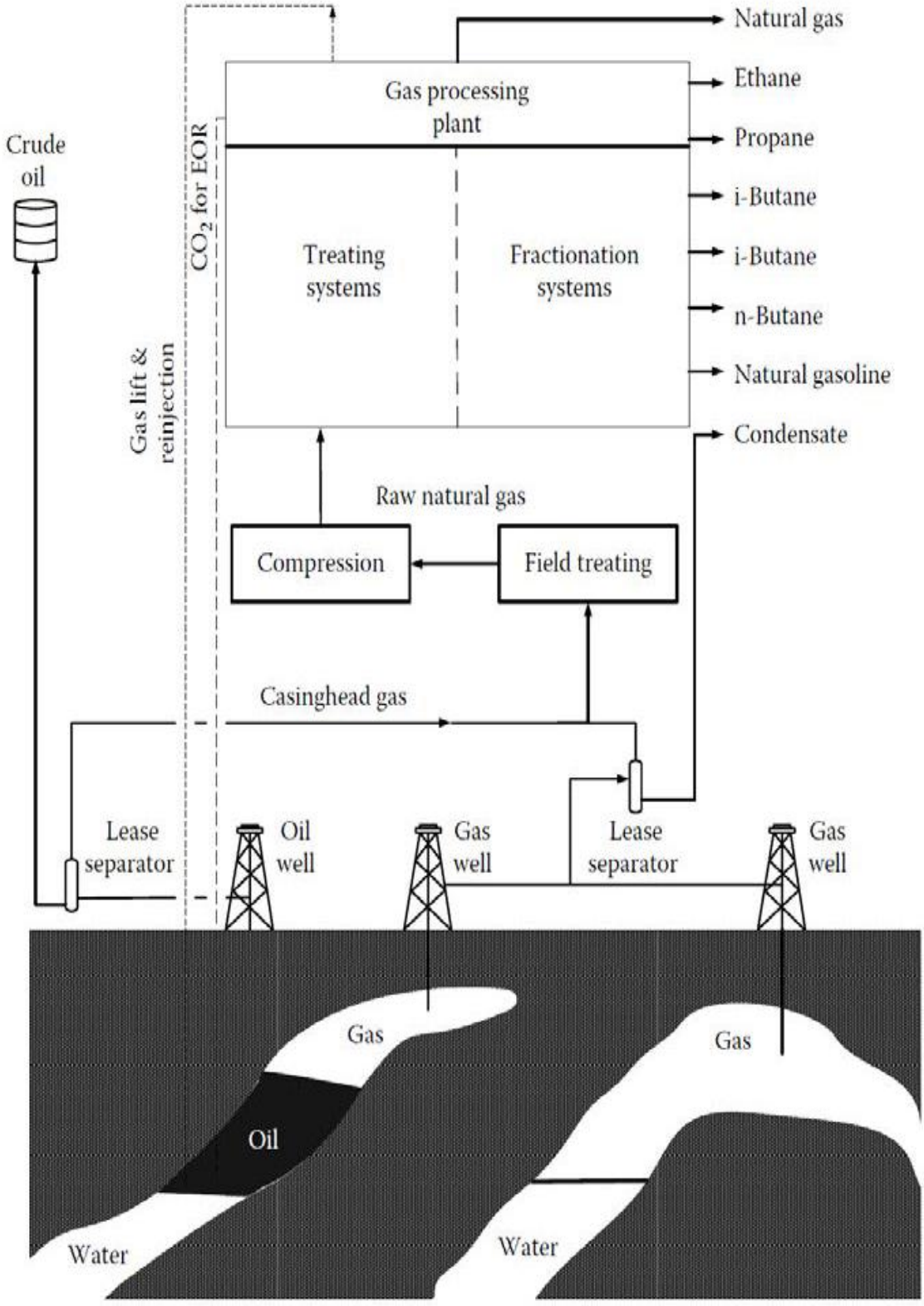

Figure 1: Schematic Overview of Natural Gas Industry**.**

Composition of natural gas

Raw natural gas typically consists primarily of methane (CH4), the shortest and lightest hydrocarbon molecule. It also contains varying amounts of:

- **Heavier gaseous hydrocarbons**: ethane **(C_2H_6)**, propane **(C_3H_8)**, normal butane **(n-C_4H_{10})**, iso-butane **(i-C_4H_{10})**, pentanes and even higher molecular weight hydrocarbons. When processed and purified into finished by-products, all of these are collectively referred to **NGL (Natural Gas Liquids)**.
- **Acid gases**: carbon dioxide **(CO_2)**, hydrogen sulfide **(H_2S)** and mercaptans such as methanethiol **(CH_3SH)** and ethanethiol **(C_2H_5SH)**.
- Other gases: nitrogen **(N_2)** and helium **(He)**.
- **Water**: water vapor and liquid water.
- **Liquid hydrocarbons**: perhaps some natural gas condensate (also referred to as **casing-head gasoline or natural gasoline)** and/or crude oil.
- **Mercury**: very small amounts of mercury primarily in elementary form, but chlorides and other species are possibly present.

The composition of natural gas varies depending on the field, formation, or reservoir from which it is extracted.

Table 1: Typical Composition of Natural Gas

Name	Formula	Volume (%)
Methane	CH_4	>85
Ethane	C_2H_6	3–8
Propane	C_3H_8	1–2
Butane	C_4H_{10}	<1
Pentane	C_5H_{12}	<1
Carbon dioxide	CO_2	1–2
Hydrogen sulfide	H_2S	<1
Nitrogen	N_2	1–5
Helium	He	<0.5

The main uses of natural gas

- Natural gas is used primarily as a **fuel and as a raw material in manufacturing**.
- It is used in home furnaces, water heaters, and cooking stoves.
- As an industrial fuel, it is used in brick, cement, and ceramic-tile kilns; in glass making; for generating steam in water boilers.
- As a clean heat source for sterilizing instruments and processing foods.
- As a raw material in petrochemical manufacturing. Ethylene, an important petrochemical, is produced from natural gas.
- Natural gas is used to produce hydrogen, sulfur, carbon black, and ammonia. The ammonia is used in a range of fertilizers and as a secondary feedstock for manufacturing other chemicals, including nitric acid and urea.
- Natural gas is considered as **an environmentally friendly clean fuel**, offering important environmental benefits when compared to other fossil fuels.