CHAPTER ONE

NATURAL GAS TECHNOLOGY

1.1 Natural Gas

Natural gas is defined as gas obtained from a natural underground reservoir. It generally contains a large quantity of methane along with heavier hydrocarbons such as ethane, propane, isobutane, normal butane, etc. Also, in the raw state it often contains a considerable amount of non-hydrocarbons, such as nitrogen, hydrogen sulphide and carbon dioxide. There are some traces of such compounds as helium, carbonyl sulphide and various mercaptans. It is also generally saturated with water. Table 1.1 below outlines the typical make up of natural gas before it is refined.

Table 1.1: Typical Raw Gas Composition

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

Table1:Typical Composition of Natural Gas

1.2 Origin & World Reserves

was Natural gas is generally considered a *nonrenewable fossil fuel*. Natural gas is called a fossil fuel because most scientists believe that natural gas was formed from the remains of tiny sea animals and plants that died 200-400 million years ago.

Briefly, 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.

1.3 Chemical Composition of Natural Gas

Natural gas is a complex mixture of hydrocarbon and nonhydrocarbon constituents and exists as a gas under atmospheric conditions. Virtually hundreds of different compounds may be present in natural gas in varying amounts. Even two wells producing from the same reservoir may produce gases of different composition as the reservoir is depleted.

The components of natural gas are either aliphatic (chain) or cyclic (ring) hydrocarbons. Their structures are as follows:

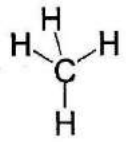
Aliphatic or Chain Hydrocarbons:

Aliphatic hydrocarbons occur in two forms: paraffin hydrocarbons and olefin hydrocarbons. The most common are saturated hydrocarbons.

- CH_4 - Methane (predominant).
- C_2H_6 – Ethane
- C_3H_8-Propane
- C_4H_{10}-Butane
- C_5H_{12}-Pentane
- C_6H_{14}-Hexane

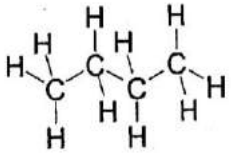
- C_7H_{16}-Heptane

The structural formula for methane is.

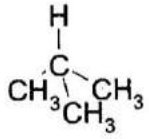


Isomer

Isomers are compounds having the same composition and molecular weight but different properties due to a different structural arrangement. The structural formulae for butane isomers are as follows:



Normal butane



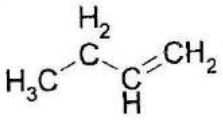
Isobutane

Olefin hydrocarbons

Olefin hydrocarbons have the general formula of CnH_2n and are classed as unsaturated hydrocarbons. They usually occur only in traces.

- C_2H_4-Ethene
- C_3H_6-Propene
- C_4H_8-Butene

The structural formula for butene is.

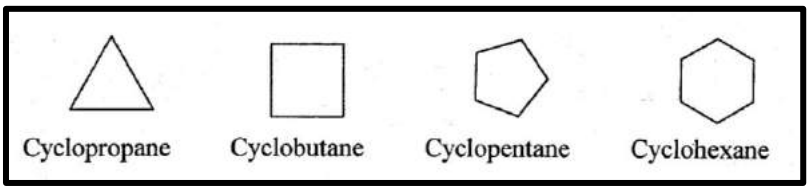


Cyclic or Ring Hydrocarbons

Cyclic hydrocarbons also occur in traces most of the time. They are of two kinds: naphthenic, and aromatic hydrocarbons. For simplicity, only the ring structures will be shown.

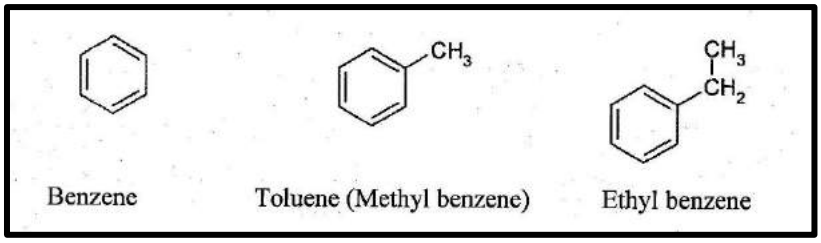
Naphthenic hydrocarbons

Naphthenic hydrocarbons are saturated cyclic hydrocarbons with the general formula of C_nH_{2n}.

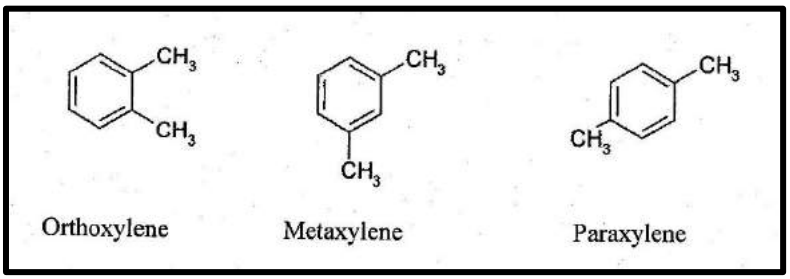


Aromatic hydrocarbons

Aromatic hydrocarbons are unsaturated cyclic hydrocarbons classified by the number of six-carbon rings in the molecule. The structures of benzene, toluene, and ethyl benzene are as follows:



Structures of more complex aromatics such as xylenes in which two or more methyl groups or side chains are attached to the benzene ring are shown below:



Nonhydrocarbon Components

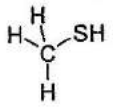
Some non-hydrocarbon components of natural gas are as follows:

Nitrogen	N_2
Carbon dioxide	CO_2
Hydrogen sulfide	H_2S
Helium	He
Water vapor	H_2O
Carbonyl sulfide	COS
Carbon disulfide	CS_2
Sulfur	S
Mercaptans	*RSH

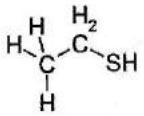
Note: R represents an alkyl group

Methyl Mercaptan and Ethyl Mercaptan

Methyl mercaptan and ethyl mercaptan are the two mercaptan compounds most commonly found in natural gas. Their structures are as follows:



Methyl mercaptan



Ethyl mercaptan

Nitrogen (N_2)

This compound is quite inert and does not contribute to the gas in any way. It should be noted that gases with high N_2 content often have high helium content.

***Hydrogen Sulphide* (H_2S)**

This compound is the cause of the sourness in natural gas. It is one of the most dangerous of industrial gases. For example, if a person is exposed to a concentration of 0.06% in air for two minutes, it will probably result in his death. Therefor, H_2S has to be removed from the raw gas. This is done, primarily by the process of sweetening. The H_2S content of gas is reduced to less than either 0.25 (4 ppm) or 1 grain (16 ppm) per 100 CF of gas, depending on the pipeline the gas is being sold to. Thus, 1 grain pipeline gas contains less than 0.0016% H_2S. The actual metric specifications are 6 mg/in or 23 mg/m^3.

Carbon Dioxide (*CO_2*)

This compound is an acid gas like H_2S, but it is not nearly so undesirable. It does not support combustion and thus does not contribute to the gas. The normal maximum acceptable concentration in pipeline gas is 2%... Often gases of higher contents are accepted from small fields as it does not pay to remove the CO_2 if only it is present. The sweetening process also is used for the removal of CO_2.

Carbonyl Sulphide (*COS*)

This is a compound that often appears in raw gases with high concentration of H_2S in them. It is generally reported in grains per 100 CF (or in ppm or mg/m^3). It has the undesirable property of forming nonregenerable compounds with one of the most commonly used sweetening agents, monoethanol amine. This causes increased chemical consumption of this agent. Other sweetening agents such as "diethanol amine", "sulphinol", etc., can be used to absorb it. The COS is generally broken down in the regeneration step with these agents.

It also contains varying amounts of:

- **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.

***Methane* (CH_4 *or* C_1)**

This is the prime compound in natural gas.

***Ethane* (C_2H_6 *or* C_2)**

This compound occurs as the second largest component of all natural gases. It has a considerably higher gross heating value than methane (1769 BTU's/SCF versus 1010 BTU's/SCF of gas or 66.0 MJ/m versus 37.7 MJ/m).

Propane (C_3H_8 *or* C_3)

This compound is a significant part of pipeline gas. However, if there is much present in the raw gas, say 2.0% or greater, then it is generally more economical to absorb it and recover it as a liquid and sell it as a liquid fuel.

***Isobutane* (i-C_4H_{10} *or* iC_4)**

This compound is normally extracted as liquid. It is used as a component in the manufacture of high-octane gasoline (alkylate).

***n-Butane* (*n-C_4H_{10} or nC_4*)**

This compound is normally extracted as a liquid. It is generally used as a blending agent in motor gasoline.

***Pentanes and Heavier* (*C_5H_{12} or C_5 or heavier*)**

These compounds appear in pipeline gas only in small quantities. They are mostly in the form of liquids when entering the processing plant. They are separated and are the primary compound in condensate.

***Mercaptans* (*CH_3SH -methyl mercaptan or C_2H_5SH -ethyl mercaptan*)**

These are very foul-smelling compounds that, in very small quantities can be used as gas odorants, but in larger quantities make the gas offensive to certain consuming areas.

Natural gas is considered **"dry"** when it is almost pure methane, having had most of the other commonly associated hydrocarbons removed. When other hydrocarbons are present, the natural gas is **"wet"**. The composition of natural gas varies depending on the field, formation, or reservoir from which it is extracted.