LNG Plant Components and Design Part 3: LNG Pretreatment Systems

An Online Continuing Education Course for Engineers

Course Number: O-2015

Credit: 2 Hours / 2 PDH / 2 CPD

LNG Plant Components and Design Part 3: LNG Pretreatment Systems

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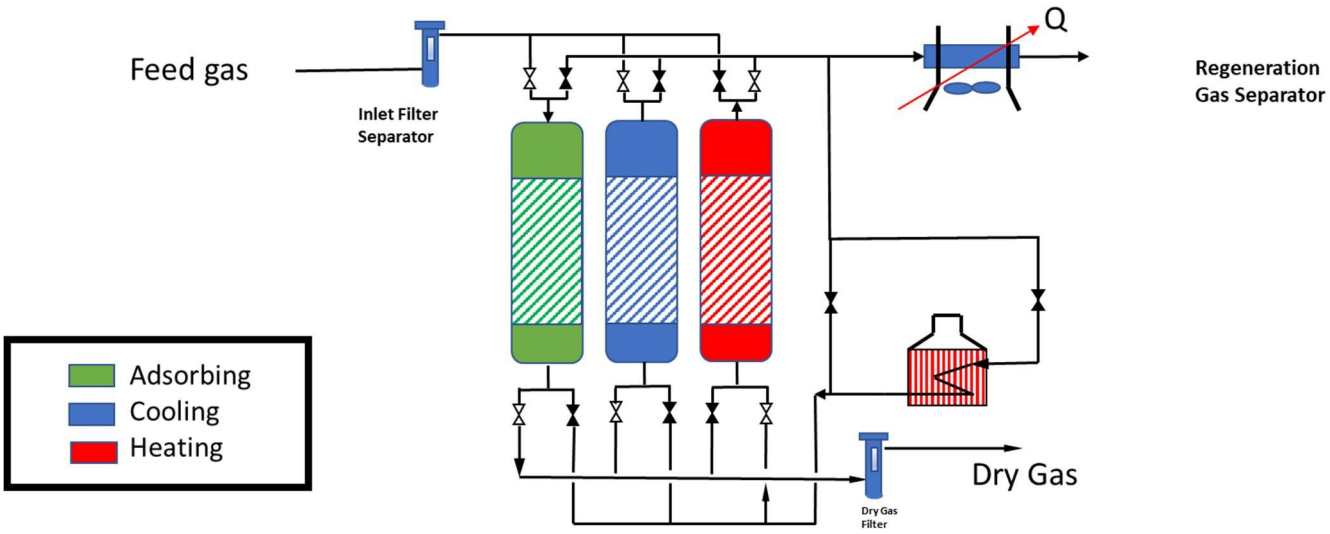


Module 3 - Natural Gas Pretreatment Systems

This course explains how and why natural gas feedstock is pretreated prior to liquefaction (conversion to LNG). It provides a technical explanation of the most common processes used to dehydrate and purify the feedstock. Because natural gas is composed of numerous organic compounds, a brief review of pertinent topics in organic chemistry is included.

ORGANIC CHEMISTRY REVIEW

Organic chemistry is the scientific study of the structure, properties, and reactions of organic compounds and organic materials. Organic matter and materials contain carbon atoms. Organic compounds always contain carbon and hydrogen but may include other elements such as nitrogen, oxygen, halogens, phosphorus, silicon, and sulfur.

Bonds:

The two main types of chemical bonds are called ionic bonds and covalent bonds. Covalent bonds may be either polar or non-polar.

Covalent Bonds - atoms share electrons to form electron pairs between them.

Nonpolar covalent bonds form when electrons are shared equally between two atoms as with atoms of equal electronegativities.

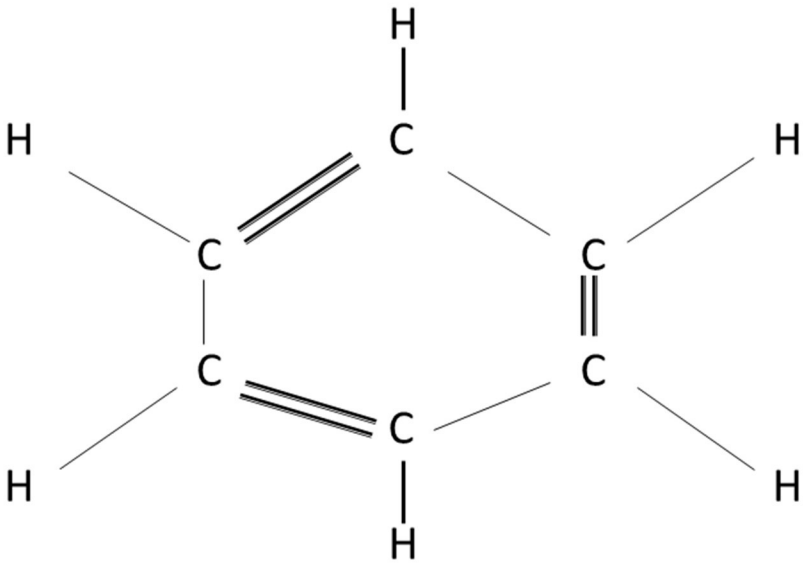
Polar covalent bonds form when carbon atoms bond to non-metals such as hydrogen, creating a molecule with an uneven distribution of electron density. As an example, water has an oxygen atom that Is more electronegative than the hydrogen atoms. Thus, the molecule exhibits a more negative oxygen end and a slightly more positive hydrogen end.

Ionic Bonds – A bond where one atom donates electrons to the other. Ionic bonds are generally stronger than covalent bonds and are usually between metals and nonmetals. For example, sodium chloride NaCl.

Carbon forms four (4) chemical bonds.
Carbon to carbon bonds are covalent.
Hydrogen forms one (1) chemical bond.
Oxygen forms two (2) chemical bonds.

Nitrogen forms three chemical bonds, as in the case of ammonia NH3.

Carbon Ring – a ring of carbon atoms, the most stable of which is a six-carbon ring in a hexagonal configuration. Cyclohexane is another name for benzene, shown below, with six carbon atoms, three double bonds, and a hydrogen atom attached to each carbon atom. In each carbon double bond, 4 electrons are shared instead of 2 as in a single bond.

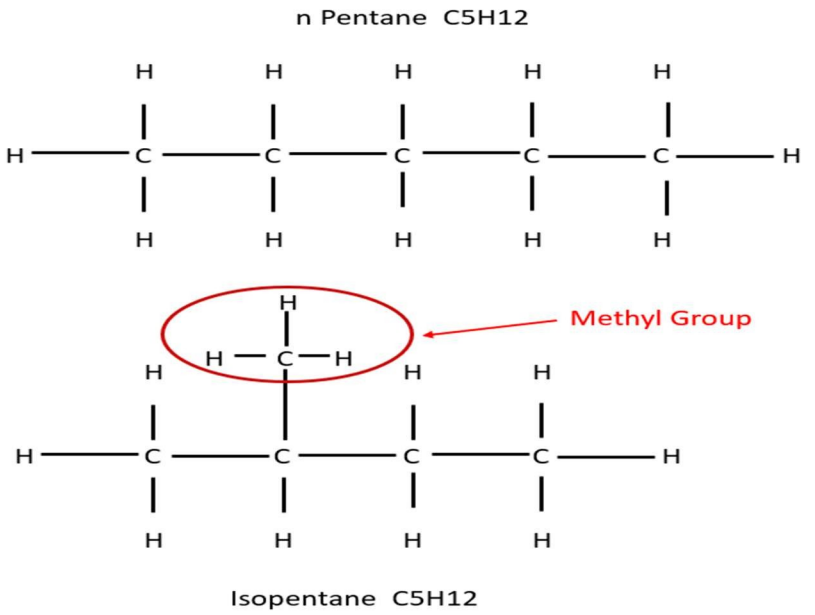


Benzene
A six carbon ring with 3 double bonds

Isomers:

Isomers are molecules that have the same molecular formula but with different arrangements of their atoms. Examples are Pentane, Isopentane, and neopentane.

Isopentane, for example, is butane substituted by a "methyl group" in place of one of the hydrogen atoms bonded to the carbon atom in position 2. A methyl group is one carbon atom bonded to three hydrogen atoms, CH3. Isopentane and n-pentane have the formula C5H12.

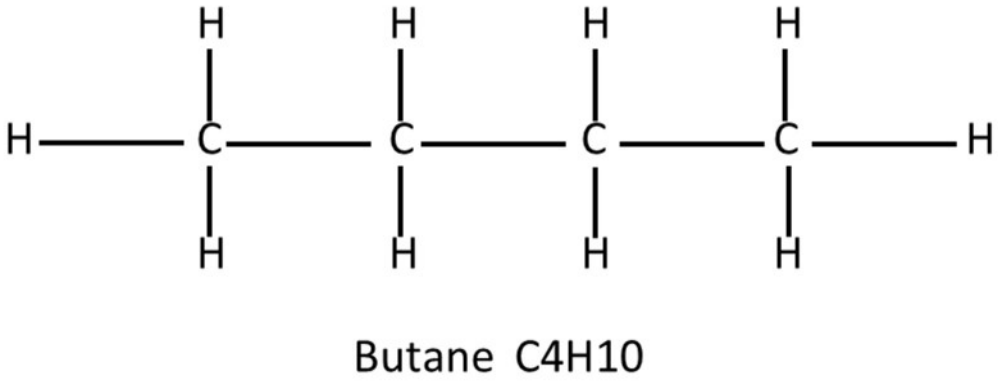


Alkanes

Alkanes are organic compounds that consist of single-bonded carbon and hydrogen atoms and lack any functional groups. Their general formula is: **CnH2n+2**

Examples of common Alkanes:

Methane: CH4 – the simplest and most common alkane
Ethane: C2H6
Propane: C3H8
Butane: C4H10



Alkanes are *saturated* hydrocarbons, meaning that each carbon atom is bonded to as many hydrogen atoms as possible. Alkanes are the principal component of many fuels and are also used as solvents, lubricants, propellants, and refrigerants.

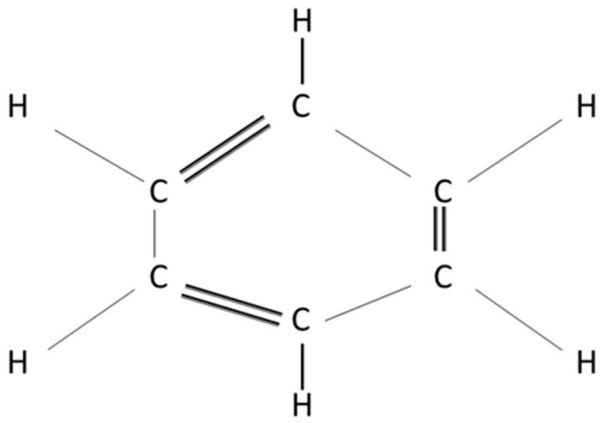
Aldehydes

A class of organic compounds in which a carbon atom shares a double bond with an oxygen atom, a single bond with a hydrogen atom, and a single bond with another atom or group of atoms.

Examples of Aldehydes:
Formaldehyde: CH2O – embalming fluids, preservative
Benzaldehyde: C6H5CHO- used in the production of dyes, soaps, and perfumes
Cinnamaldehyde: C9H8O – gives cinnamon its flavor and odor

Aromatics – a family of liquid hydrocarbons that are found in crude oil and can often be present in trace quantities in natural gas. They tend to freeze at temperatures above the process temperatures for LNG plants and need to be removed by the pretreatment system. Aromatics are a class of unsaturated organic compounds with one or more ring-shaped, planar structures made up of atoms held together by alternating single and double bonds. The most common aromatic compounds are derivatives of benzene. They are considered unsaturated because there are one or more carbon atoms available to bond with an additional hydrogen atom. Aromatics are very stable and unreactive because their bonding arrangement causes certain electrons to be strongly held. Although many aromatics have a distinctive odor, they are classified as aromatics based on their chemical bonding structure alone. Odor does not make a compound aromatic.

Benzene C6H6



Benzene is a colorless or light yellow aromatic compound. It is a highly flammable liquid that is found in gasoline. It is a well-known carcinogen. It is used to make plastics, foams, dyes, solvents, and insecticides.

Ethylbenzene C_8H_{10} is used to make paints, fuels, and inks.

A colorless, flammable liquid that smells like [illegible] is used in the [illegible] of many chemicals, including styrene, synthetic polymers, and [illegible] tar and its vapors are heavier than air. Its [illegible]

Toluen[illegible]

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Xylene (c[illegible]
A colorle[illegible]ethylbenzene.

Aliphatic [illegible]

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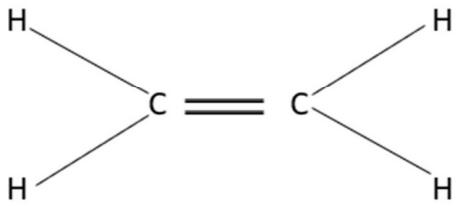
Propane
Saturated aliphatic



Ethene
Saturated aliphatic