Petroleum Refinery

Refinery Feedstocks and Products

1. Introduction

- A petroleum refining study starts with describing its feedstock, the crude oil and the range of products that are produced by the various processes.
- Crude oil comes from different parts of the world and has different physical and chemical characteristics.

2. Composition of Crude Oils

- Crude oil is a complex liquid mixture made up of a vast number of hydrocarbon compounds that consist mainly of carbon and hydrogen in differing proportions.
- In addition, small amounts of organic compounds containing sulphur, oxygen, nitrogen and metals such as vanadium, nickel iron and copper are also present.

Table 1. Elemental composition of crude oils

Element	Composition (wt%)
Carbon	83.0–87.0
Hydrogen	10.0–14.0
Sulphur	0.05–6.0
Nitrogen	0.1–0.2
Oxygen	0.05–2.0
Ni	<120 ppm
V	<1200 ppm

- **There are three main classes of hydrocarbons. These are based on the type of carbon–carbon bonds present:**
- ***Saturated hydrocarbons*** contain only carbon–carbon single bonds. They are known as paraffin's (or alkanes) if they are acyclic, or naphthenic (or cycloalkanes).
- ***Unsaturated hydrocarboné*** contain carbon–carbon multiple bonds (double, triple or both). These are unsaturated because they contain fewer hydrogens per carbon than paraffins. Unsaturated hydrocarbons are known as olefins. Those that contain a carbon–carbon double bond are called alkenes, while those with carbon–carbon triple bond are alkynes.
- ***Aromatic hydrocarbons*** are special class of cyclic compounds related in structure to benzene.

2.1. Paraffin's

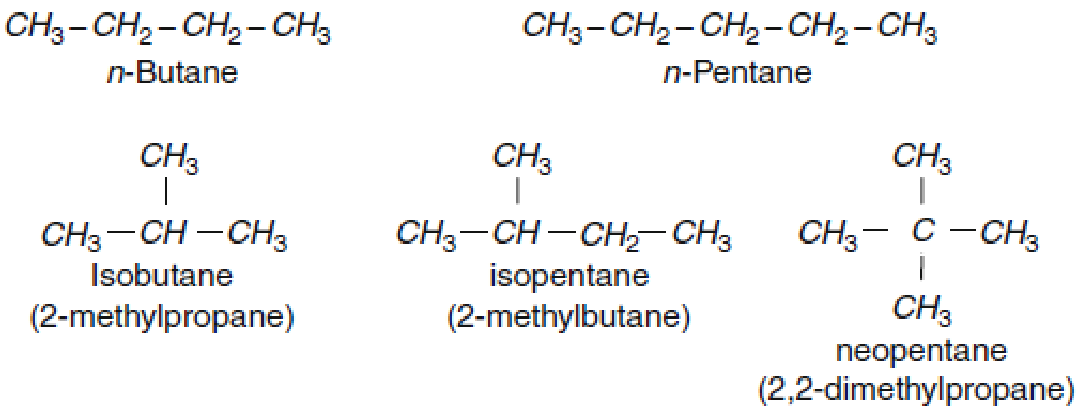
- Paraffin's, also known as alkanes, are saturated compounds that have the general formula C_nH_{2n+2}, where n are the number of carbon atoms. The simplest alkane is methane (CH_4), which is also represented as C_1.
- ***Normal paraffin's (n-paraffin's or n-alkanes)*** are unbranched straight chain molecules.They have similar chemical and physical properties, which change gradually as carbon atoms are added to the chain.

Table 2. Names and formulas of the first ten parrafins (alkanes)

Name	Number of carbon atoms	Molecular formula	Structural formula	Number of isomers
Methane	1	CH_4	CH_4	1
Ethane	2	C_2H_6	CH_3CH_3	1
Propane	3	C_3H_8	$CH_3CH_2CH_3$	1
Butane	4	C_4H_{10}	$CH_3CH_2CH_2CH_3$	2
Pentane	5	C_5H_{12}	$CH_3(CH_2)_3CH_3$	3
Hexane	6	C_6H_{14}	$CH_3(CH_2)_4CH_3$	5
Heptane	7	C_7H_{16}	$CH_3(CH_2)_5CH_3$	9
Octane	8	C_8H_{18}	$CH_3(CH_2)_6CH_3$	18
Nonane	9	C_9H_{20}	$CH_3(CH_2)_7CH_3$	35
Decane	10	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	75

- ***Isoparaffins (or isoalkanes)*** are branched-type hydrocarbons that exhibit structural isomerization. Structural isomerization occurs when two molecules have the same atoms but different bonds. In other words, the molecules have the same formulas but different arrangements of atoms, known as isomers.

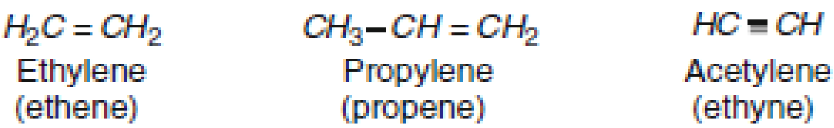
- Butane and all succeeding alkanes can exist as straight-chain molecules (n-paraffin's) or with a branched-chain structure (isoparaffins). For example, butane and pentane have the following structural isomers:



2.2. Olefins

- Olefins, also known as alkenes, are unsaturated hydrocarbons containing carbon–carbon double bonds. Compounds containing carbon–carbon triple bonds are known as acetylenes, and are also known as biolefins or alkynes. The general formulas of olefins and acetylenes are C_nH_{2n} and C_nH_{2n-2} respectively.

- Unsaturated compounds may have more than one double or triple bond. Olefins are not naturally present in crude oils but they are formed during the conversion processes. They are more reactive than paraffins. The lightest alkenes are ethylene (C_2H_4) and propylene (C_3H_6), which are important feedstocks for the petrochemical industry. The lightest alkyne is acetylene.

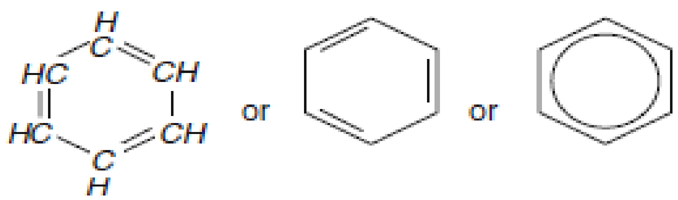


2.3. Naphthenes (cycloalkanes)

- Naphthenes, also known as cycloalkanes, are saturated hydrocarbons that have at least one ring of carbon atoms. They have the general formula C_nH_{2n}. A common example is cyclohexane (C_6H_{12}).

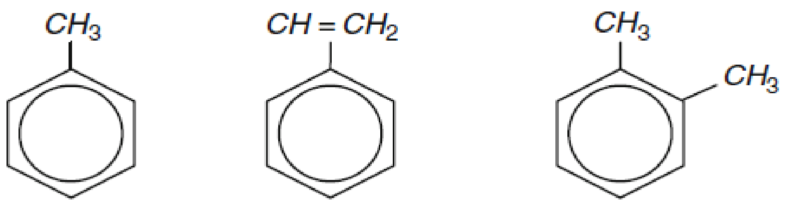
2.4. Aromatics

- Aromatics are unsaturated cyclic compounds composed of one or more benzene rings. The benzene ring has three double bonds with unique electron arrangements that make it quite stable.



Benzene

- Examples of these compounds are toluene and xylene. Together with benzene, such compounds are important petrochemical feedstock.



Toluene (methylbenzene) | Styrene | o-xylene (1,2-Dimethylbenzene)

2.5. Sulphur Compounds

- The Sulphur content of crude oils varies from less than 0.05 to more than 10 wt% .Crude oil with less than 1 wt % sulphur is referred to as low sulphur or sweet, and that with more than 1 wt% sulphur is referred to as high sulphur or sour.
- Crude oils contain sulphur in the form of elemental sulphur S, dissolved hydrogen sulphide H_2S, carbonyl sulphide COS, inorganic

2.6. Oxygen Compounds

- The oxygen content of crude oil is usually less than 2 wt%. Oxygen in crude oil can occur in a variety of forms. These include alcohols, ethers, carboxylic acids, phenolic compounds, ketones, esters and anhydrides. The presence of such compounds causes the crude to be acidic with problems such as corrosion. *Alcohols* have the general formula R–OH.

2.7. Nitrogen Compounds

- Crude oils contain very low amounts of nitrogen compounds. In general, the more asphaltic the oil the higher its nitrogen content. Nitrogen compounds are more stable than sulphur compounds and therefore are harder to remove.
- Even though they are present at very low concentrations, nitrogen compounds have great significance in refinery operations. They can be responsible for the poisoning of a cracking catalyst, and they also contribute to gum formation in finished products.

2.8. Metallic Compounds

- Metallic compounds exist in all crude oil types in very small amounts. Their concentration must be reduced to avoid operational problems and to prevent them from contaminating the products. Metals affect many upgrading processes. They cause poisoning to the catalysts used for hydroprocessing and cracking.

- Even minute amounts of metals (iron, nickel and vanadium) in the feedstock to the catalytic cracker affect the activity of the catalyst and result in increased gas and coke formation and reduced gasoline yields.

- For high-temperature power generators, the presence of vanadium in the fuel may lead to ash deposits on turbine blades and cause severe corrosion, and the deterioration of refractory furnace linings.

2.9. Asphaltenes and Resins

- ***Asphaltenes*** are dark brown friable solids that have no definite melting point and usually leave carbonaceous residue on heating.
- The presence of high amounts of asphaltenes in crude oil can create tremendous problems in production because they tend to precipitate inside the pores of rock formations, well heads and surface processing equipments. They may also lead to transportation problems because they contribute to gravity and viscosity increases of crude oils. In refinery operations, asphaltenes have markedly adverse effects on the processability of crude oils. They lead to coke formation and metal deposition on the catalyst surface causing catalyst deactivation.

- ***Resins*** are polar molecules in the molecular weight range of 500–1000, which are insoluble in liquid propane but soluble in n-heptane. The resin molecules surround the asphaltene and suspend them in liquid oil. Because each asphaltene is surrounded by a number of resin molecules, the content of resins in crude oils is higher than that of the asphaltenes.

3. Products Composition

- There are specifications for over 2000 individual refinery products. Intermediate feed stocks can be routed to various units to produce different blend products depending on market demand. Figure 1 shows typical refinery products with their carbon atom contents and boiling ranges. The specifications of each product are discussed in detail in the coming Subsections.

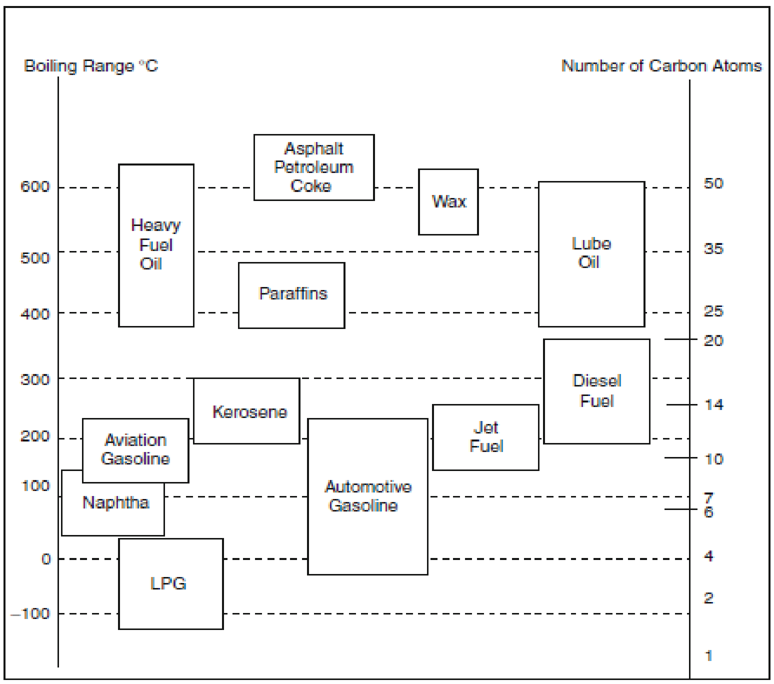


Figure1. Principal petroleum products with carbon numbers and boiling ranges

3.1. Liquefied Petroleum Gas (LPG)

- Liquefied petroleum gas is a group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane and isobutylene. For convenience of transportation, these gases are liquefied through pressurization.

3.2. Gasoline

Gasoline is classified by octane ratings (conventional, oxygenated and reformulated) into three grades: Regular, Midgrade and Premium.

- Regular gasoline: Gasoline having antiknock index, i.e. octane rating, greater than or equal to 85 and less than 88.
- Mid-grade gasoline: Gasoline having octane rating, greater than or equal to 88 and less than or equal to 90.
- Premium gasoline: Gasoline having octane rating greater than 90.

Premium and regular grade motor gasoline are used depending on the octane rating. In addition, aviation gasoline, which is a complex mixture of relatively volatile hydrocarbons, is blended with additives to form suitable fuel for aviation engines.

3.3. Kerosene

- Kerosene is a light petroleum distillate that is used in space heaters, cook stoves and water heaters and which is suitable for use as a light source.
- Kerosene has a maximum distillation temperature of 204°C (400°F) at the 10% recovery point, a final boiling point of 300°C (572°F), and a minimum flash point of 37.8°C (100°F). The two grades are recognized by ASTM Specification D3699. A kerosene-type jet fuel-based product is having a maximum distillation temperature of 204°C (400°F) at the 10% recovery point and a final maximum boiling point of 300°C (572°F) and meeting ASTM Specification D1655.

3.4. Jet Fuel

- This category comprises both gasoline and kerosene and meets specifications for use in aviation turbine power units.

3.5. Diesel Fuel

- The quality of diesel fuels can be expressed as cetane number or cetane index. The cetane number (CN) is expressed in terms of the volume percent of cetane ($C_{16}H_{34}$) which has high ignition (CN = 100) in a mixture with alpha-methyl-naphthalene ($C_{11}H_{10}$) which has low ignition quality (CN = 0).

Diesel fuel includes No.1 diesel (Super-diesel) which has cetane number of 45 and it is used in high speed engines, trucks and buses. Railroad diesel fuels are similar to the heavier automotive diesel fuels, but have higher boiling ranges upto 400°C(750°F) and lower cetane numbers (CN = 30).

3.6. Fuel Oil

- The fuel oils are mainly used in space heating and thus the market is quite high especially in cold climates.

3.7. Residual Fuel Oil

- It is mainly composed of vacuum residue. Critical specifications are viscosity and sulphur content. Low sulphur residues are in more demand in the market.

3.8. Lube Oil

- Lubricants are based on the viscosity index. Paraffinic and naphthenic lubricants have a finished viscosity index of more than 75.

3.9. Asphalt

- Asphalt is an important product in the construction industry and comprises up to 20% of products. It can be produced only from crude containing asphaltenic material.

3.10. Petroleum Coke

- Carbon compounds formed from thermal conversion of petroleum containing resins and asphaltenes are called petroleum cokes. Fuel grade coke contains about 85% carbon and 4% hydrogen. The balance is made up of sulphur, nitrogen, oxygen, vanadium and nickel.

Physical properties of feedstock's and products

1)^{o}API (American petroleum institutes)

It's a scale expressing the gravity or density of liquid petroleum products'. ^{o}API gravity is a measure of how heavy or light a petroleum liquid is compared to water.

^{o}API = (141.5/SG) – 131.5 The purpose of this equation was to extend the range of the specific gravity scale.

^{o}API = (10 – 50).

2)Viscosity:

The viscosity of an oil is a measure of its resistance to internal flow and is indication of its oiliness in the lubricating of surface.

Tom other common terms are:

a) Kinematic viscosity: which is the viscosity in centistoke.

b) dynamic viscosity: which is the viscosity in centipoise.

3)Pour Point:

Its temperature at which oil ceases to flow

.

4)Flash Point:

The lowest temperature at which the vapor above an oil will momentarily flash or explode when in the presence of aflame and the temperature at which the vapour are evolved rapidly enough to burn continuously.

5)Vapor Pressure:

Also known as Reid vapor pressure (RVP). True vapor pressure

6)Carbon Residue:

The solid residue (%wt) remaining after heating to coking temperatures (700-800^{o}C)

7)Salt Content:

Desalting is necessary because leads to corrosion.

8)Metals:

Include Ni, V, Ag, Hg, Na, and Ca. Metals can cause catalyst deactivation and corrosion.

9)Sediment and Water:

These inorganic particles can lead to operational problems.

10)Acidity:

11)Sulfur:

Sour crudes > 0.5 wt% and sweet crudes < 0.5 wt% . Today it is difficult to find crudes below 1% sulfur.

12)Specifications for Gasoline and Diesel

Gasoline-octane number

Octane of straight run crude oil is 0 ~ 40

13)Diesel-cetane number

The desirable range for the cetane number is between 40-50

Evaluation of Crude Oil

1) Specific Gravity and API Gravity:

Specific gravity and API (American Petroleum Institute) gravity are expressions of the density or weight of a unit volume of material.

The specific gravity is the ratio of the weight of a unit volume of oil to the weight of the same volume of water at a standard; both specific gravity and API gravity refer to these constants at 60 ^{0}F (16 ^{0}C).

$$API = \frac{141.5}{Sp.gr.} - 131.5$$

or

$$Sp.gr. = \frac{141.5}{API. + 131.5}$$

Corresponding values of API gravity (0 to 100)

2) Characterization Factor: (C.F), (K)

The most widely used index is characterization factor and

It was originally defined as:

$$K = \frac{\sqrt[3]{T_B}}{S}$$

In which:

TB is the average molal boiling point (R)

S: is the specific gravity at 60 ^{0}F

It has since related to viscosity, aniline, temperature, molecular weight, critical temperature, percentage of hydrocarbon etc.

$K \geq 12.15$ (Paraffinic Base)

$K < 11.5$ (Napthene Base)

K between 11.5-12.15 (Intermediate Base)

3) Correlation Index: (C.I)

Like (C.F) related to boiling point and gravity

$$C.I = \frac{48640}{T_B} + 473.7S - 456.8$$

TB is the average modal boiling point (K)

S: is the specific gravity at 60 ^{0}F

C.I for Parafine =0

C.I for Benzene =100

C.I =0-15 Parafine

C.I =15-50 either Naphtenes or mix (Parafine + Naphtenes)

C.I = above 50 Aromatic

4) Viscosity Index : (V.I)

A series of numbers ranging from 0-100 which indicate the rate of change of viscosity with temperature.

Paraffinic base C.O V.I =100

Naphthenic base C.O V.I = 40

Some Naphthenic base C.O V.I =0

The presence of impurities in the crude oil:

1. Sulfur:

2. Salt:

Salt carried into the plant in brine associated with crude oils is a major cause of the plugging of exchangers and coking of pipe still tubes.

If salt content expressed as NaCl , is greater than 10 lb/1000 bbl, it is generally necessary to desalt the crude before processing.

3. Carbon Residue:

The less the value of carbon residue the more valuable the crude.

4. Hydrocarbons Gaseous:

The amount of gaseous hydrocarbons dissolved in crude oil .The percentage of involved when the dissolved gases are lost cannot be stated with accuracy but it is about

$$\text{Liquid vol. \% loss} = \frac{\text{Reid V. P} - 1}{6}$$

5. Metallic Content (Ni, V, Cu):

The metal content in crude oil can vary from a few ppm to more than 1000 ppm, disadvantages affect activities of catalyst, corrosion, deterioration of refractory furnace lining and stacks. Can be reduced by solvent extraction with C_3.

Pipe Still Heater:

Crude oils are heated in pipe still heater before entering into the atmospheric distillation column. This heater is a special type of furnace which heats crude oil up to about 350℃ depending on the type of feed. .A large number of tubes connected through bends is housed within the furnace in multiple rows. The still is built with two distinct heating sections, a radiant section, which can receive heat directly from the flame and a convection section, which takes heat from the hot gases travelling to the stack.

Applications of pipe heaters in oil & gas

- Also called drywall heaters, pipe heaters are useful in several oil and gas applications. They can withstand caustic and corrosive materials, as well as reaching high temperatures. Some common applications of pipe heaters in the oil and gas industry include:
- Tank heating
- Pipe heating
- Freeze protection

Pipe heaters can be categorized into three types:

1) Box/ Rectangular.
2) Cylindrical.
3) Radiant Wall

Processing of petroleum liguid:

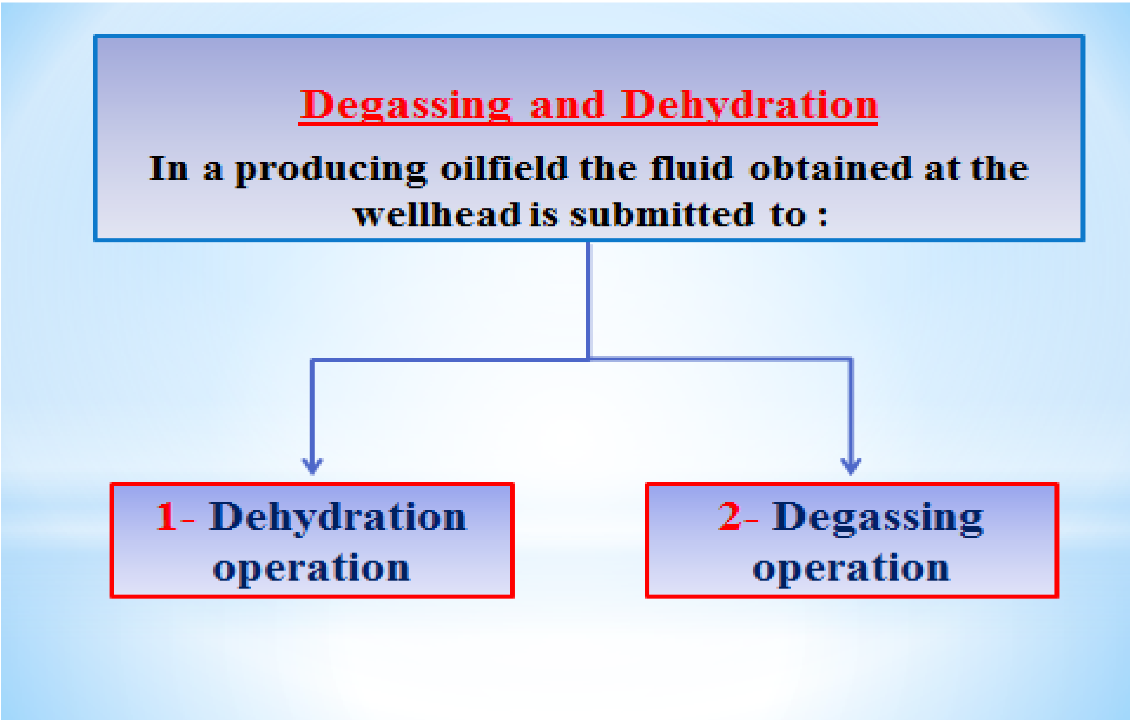
In an oil field the oil is generally mixed with

1) Associated.

2) Production water.

3) Hydrogen sulfide.

4) Salts.



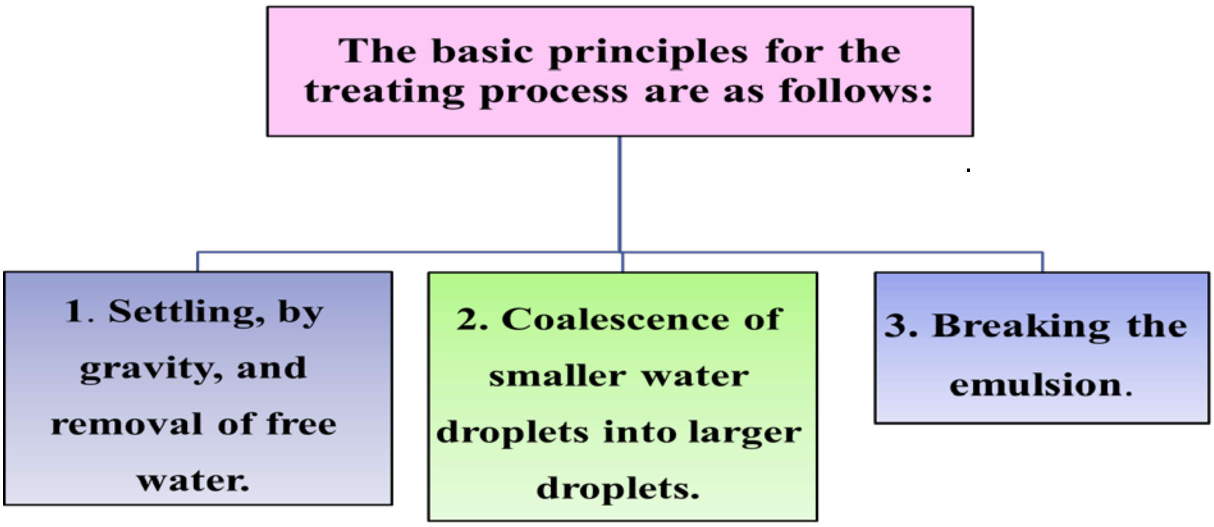
1- Degassing: -

At the high pressure existing at the bottom of the producing well, crude oil contains great quantities of dissolved gases. When crude oil is brought to the surface, it is at a much lower pressure., the gases that were dissolved in it at the higher pressure tend to come out from the liquid.

2) Dehydration or Desalting

The fluid produced at the wellhead consists usually of gas, oil, free water, and emulsified water (water–oil emulsion). Before oil treatment begins, we must first remove the gas and free water from the well stream. This is essential in order to reduce the size of the oil–treating equipment.

The operation aim of this to completely eliminate the water that appears in the fluid forming stable emulsions, and the removal of water-soluble inorganic salts associated with the water which, if left in the oil, would give rise to serious corrosion problems in the course of refining operation. All crude contain moisture and salts to varying degrees. Water is likely to occur in emulsion form when the crude are naphthenic or sulfurous. Water being good solvent for these salts the removal is very much effective in the form of brine.



3. Breaking the emulsion:-

which could be achieved by:

- a combination of the addition of heat the addition of chemicals.
and the application of electrostatic field.

Emulsions:

Oil emulsions are mixtures of oil and water.

In general, an emulsion can be defined as a mixture of two immiscible liquids, one of which is dispersed as droplets in the other (the continuous phase)as show in fig 1, and is stabilized by an emulsifying agent. In the oil field, crude oil and water are encountered as the two immiscible phases together. They normally form water-in-oil emulsion (W/O emulsion), in which water is dispersed as fine droplets in the bulk of oil. This is identified as type C in Figure 2.

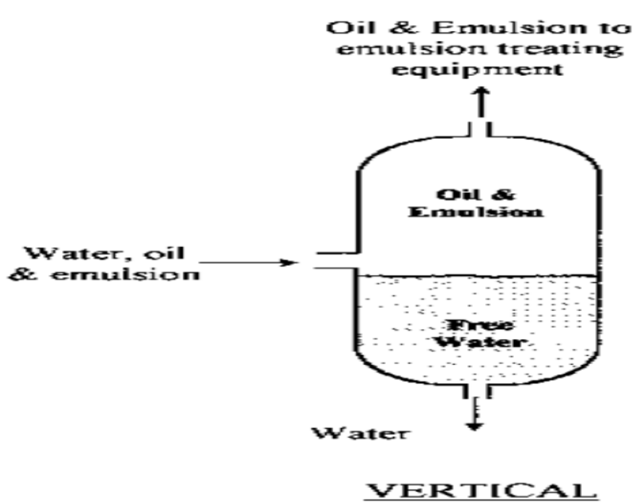


Fig 1

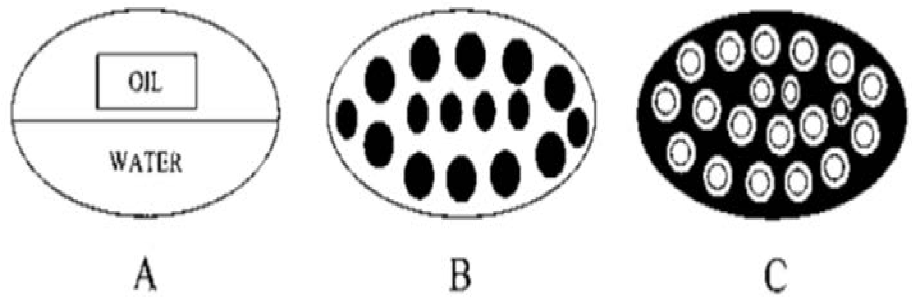
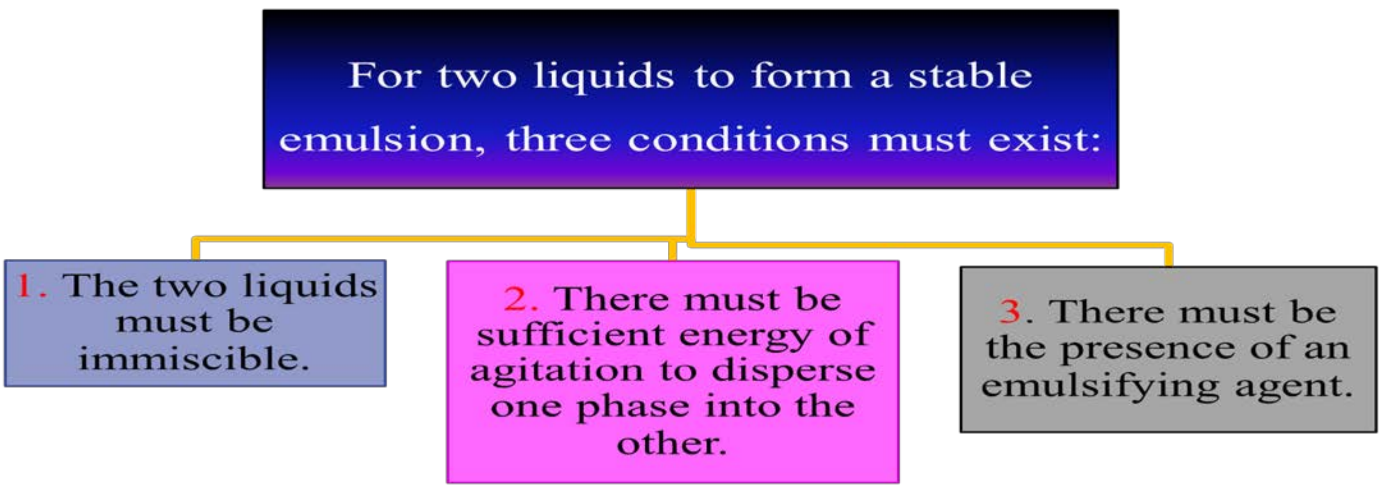


Figure 2 Schematic representation of (A) a non-dispersed system, (B) an O/W emulsion, and (C) a W/O emulsion.



Emulsifying agent are generally

Resin, asphalts, organic acids, and solids which are produced with the oil, and aid in the formation of a tough film around the droplet, thus isolating each separate water droplet from the other. The film which isolates the water droplets from the other must be broken before coalescence take place.

Some of the common emulsifiers are as follows:

1. Asphaltic materials
2. Resinous substances
3. Oil-soluble organic acids
4. Finely dispersed solid materials such as sand, carbon, calcium, silica, iron, zinc, aluminum sulfate, iron sulfide, and so on.

Atmospheric distillation:

Atmospheric distillation also known as: atmospheric tower, primary distillation, crude distillation unit(CDU) , fractional distillation

Atmospheric distillation is the first and most fundamental step in the the refining process. The primary purpose of the atmospheric distillation tower is to separate crude oil into its components .All crude oil processed must first go through atmospheric distillation. Also atmospheric distillation typically provides most of the feed for the other process units in the refinery.

In most refineries, the bottoms from the atmospheric distillation tower will be sent to the vacuum tower for further separation.

How it works

Crude oil is first heated to about 700-750F (400C). The heated crude is injected into the lower part of the distillation column, where much of it vaporizes. As the vapors rise through the tower, they pass through a series of perforated trays. As the vapors cool, their components will condense back into liquid at different levels in the tower based on their boiling point. A portion of the vapors reaches the top of the column, where it is cooled through heat exchangers and air coolers and partly converted back into liquid. A portion of this is fed back into the distillation column as a reflux stream to contact with the rising vapors, helping to cool them. This effect of counter-current flows of rising vapors meeting falling cooler liquids allows equilibrium conditions to be established throughout the column. The lighter hydrocarbons will condense at higher points in the distillation tower; heavier hydrocarbons will condenser lower down. This results in separation of the hydrocarbons based on the different temperatures at which they boil/condense. Hydrocarbons are drawn off of the tower at different heights to get a set of streams of different boiling points. These different streams are called distillation cuts or fractions. These individual streams are then sent to other units for further processing or to finished product blending. The heaviest fractions of the crude do not vaporize and are drawn off at the bottom of the tower as atmospheric bottoms. These are sent to the vacuum distillation for further fractionation under a vacuum.

Crude with high salt content will typically be processed through a desalted before going to distillation, to remove salts that could cause corrosion in the distillation tower.

Inputs:

The primary input to an atmospheric distillation unit is crude oil. This can be a single crude oil or a mixture of several different crude oil grades.

Products:

The outputs from distillation are distillation cuts. Typically, a crude distillation unit will have the following distillation :

- Refinery gas - Made up of methane and ethane. This stream remains a gas and is used as fuel for the refinery.
- Light gas - Stream containing primarily propane and butane. It is sent to the sat gas plant for further separation.
- Light naphtha - Sold as a feedstock for petrochemicals, blended directly into gasoline .
- Heavy naphtha - blended directly into gasoline.
- Kerosene - Used to make jet fuel or blended into diesel.
- Atmospheric gasoil - Used to make diesel or converted to gasoline.
- Atmospheric bottoms - Contains all of the hydrocarbons that do not vaporize in the atmospheric distillation tower.

Vacuum Distillation Units:

Also known as: vac tower, vacuum unit, vacuum flasher, VDU

Vacuum distillation is a part of the refining process that helps to produce petroleum products out of the heavier oils left over from atmospheric distillation. In the refining process, the atmospheric distillation unit (ADU) separates the lighter hydrocarbons from the heavier oils based on boiling point. This technique separates compounds based on differences in boiling points. Vacuum distillation often improves efficiency.

How it work:

Atmospheric tower bottoms are injected into the vacuum tower under a pressure at about 1/20th of atmospheric pressure (typically 25 to 40 mmHg or lower). Under these low pressures vaporize at temperatures below those where it starts to crack. This allows separation of very heavy components without cracking

How is vaccum created?

A vacuum can be created by removing air from a space using a vacuum pump or by reducing the pressure using a fast flow of fluid, as in Bernoulli's principle.

What is the advantage of vaccum distillation?

Using vacuum is often preferable for the following reasons: Faster processing time; Effective distillation while keeping the process under the maximum temperature of the distillation unit's heater; and. Effective processing of higher boiling point solvents without igniting them or causing thermal breakdown.

product of vaccum distillation:

1. Light gas oil.
2. Heavy gas oil.
3. vacuum Residue.

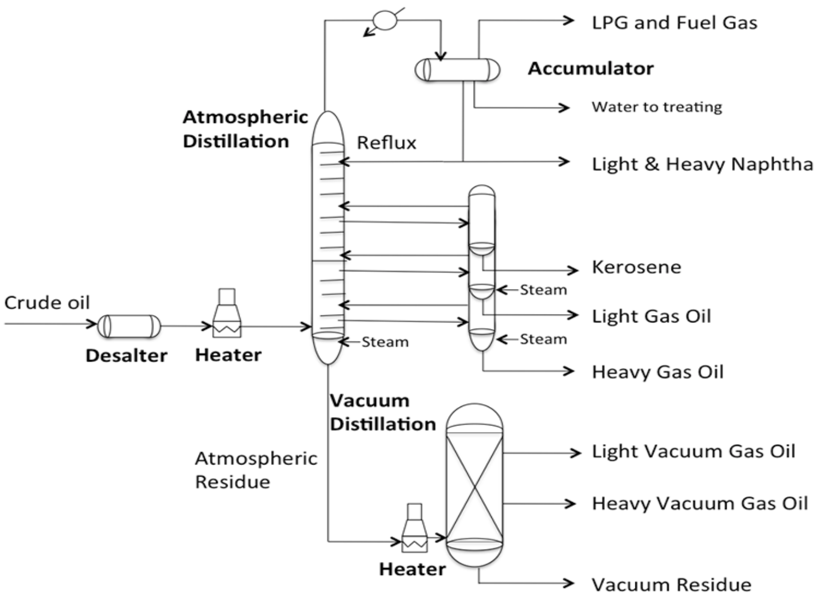


Figure 1 vacuum and atmospherics distillation of crude oil

Gas

Gas from petroleum is classified under several names

a) **Natural gas:**

It is readily available in nature, in almost as a finished product. It contains mainly methane It may be accompanied by other dry fractions like ethane and propane to a small extent. In addition to these combustibles some inert like CO_2, N_2, and noble gases are also present. The proportion of methane ranges from 85% to 98%.

b) **Associated gas:**

This is obtained from oil reservoirs and this exists as a separate gas cap over liquid phase. The proportion of CH_4, C_2H_4, and C_3H_8 vary depending on reservoir conditions. When the gas phase is taken out, it may still contain some liquid, hydrocarbons mainly of volatile range like butane and pentane which when condensed are treated as *(Natural Gasoline)*.

c) **Dissolved gas:**

Gas may be present in liquid HC mainly in the dissolved state depending upon the formation pressure. When the pressure decreased, this dissolved gas comes out of the oil. This gas is separated before transportation in pipe lines or tankers. The remaining is first to come out of the distillation column because of higher temperature.

d) **Refining off gas:**

In refinery, gas is formed in cracking and reforming operations due to the thermal degradation of liquid hydrocarbons. During stabilization of wild gasoline or possessed gasoline, the gases are vented. This forms a major source of heat energy for refinery, as well as feed stock for petrochemicals. All the gases contain impurities like CO_2, N_2, mercaptans, H_2S, water vapor, suspended impurities. First three paraffin are gases at room temperature. The mixture of methane and ethane is called dry gas, propane and butane mixture is called wet gas.

e) Liquefied Petroleum Gas (LPG):

Propane is frequently used as LPG after being mixed with butane. The most important property of this fuel is the vapor pressure.

For factiliting leak detection, the gas is mixed with small amount of odorous mercaptans.

Gasoline

Gasoline is a complex mixture of hydrocarbons C4-C12 having a boiling range from 100 to 400 ^{o}F Components are blended to promote:

1) High antiknock property. 2) Ease of starting. 3) Quick warm-up. 4) Low tendency to vapor lock. 5) Low engine deposits.

Normal butane is blended into gasoline to give the desired vapour pressure

The most important properties are:

1) Boiling Range:

This governs ease of starting, rate of acceleration, loss by crankcase dilution. And tendency towards vapor lock.

2) Antiknock Properties:

There are two types of octane numbers for gasoline engines: those determined by

- the motor method (MON)
- the research method (RON)

both methods use the same basic test engine but operate under different conditions.

Distillate Fuels

1) Jet Fuels:

Commercial jet fuel is a material in the kerosine boiling range and must be clean burning. One of the critical specifications of jet fuels is its **smoke point** and this limits the % of cracked products high in aromatic that can be incorporated.

Specification limits the aromatic conc. to 20%.Hydrocracking saturates the aromatics in the cracked products and raise the smoke point.

The freeze point

Specification is very low (-40 ^oF to -58 ^oF) max. and hydrocracking is also used to isomerize paraffin's and lower the freeze point.

2) Diesel Fuels:

The major performance characteristics of diesel fuels, somewhat in the order of importance are: (cleanliness, ignition quality, volatility, viscosity).

<u>Limiting specifications are</u>

The ignition properties of diesel fuels are expressed in terms of cetane number which expressed the volume % of cetane ($C_{16}H_{34}$, high ignition quality) in a mixture with alpha-methl-naphthalene ($C_{11}H_{10}$, low ignition quality).

3) Heating Oils

fuel oil is very similar to kerosene but has a higher pour point and end point.

<u>Limiting specification are</u>

Distillation, pour point, flash point and sulfur content.

fuel oil is very similar to diesel fuel, contains cracked stock, and is blended from naphtha, kerosene, and diesel and cracked- cycle oils.

Naphtha:

These fractions are highly volatile and fall in the boiling range of motor spirits.

These are mostly used as solvents in paints, perfumery and other industries. Solvent grades are produced by distilling wide cut naphtha into small boiling range cuts.

Naphtha are not suitable for combustion because of the rapid flame propagation, resulting in explosions.

Cuts boiling below 80^{o}C do not have any aromatics, hence their solvent power is also less, and such fractions are sent for cracking operations.

Approx. boiling point range 150-250 ^{o}C,Low viscosity,Good degree of refinement to be fairly stable,Light in colour, Free from smoke

*Used as illuminating oil,*Boiling point range 250-320 ^{o}C

Mainly two types: classification of diesel oils is done according to speed and load of the engine as1) High speed diesels, 2) Low speed diesels.

Lube Oils:

The principal source of lubricating oil is the fraction that is left after components, namely gasoline, kerosene, diesel oil during crude distillation.

Boiling point >350 ^{o}C

Otained from vacuum distillation units.

Residuums after precipitation of asphaltenes are known as bright stocks and form good source for lube oils.

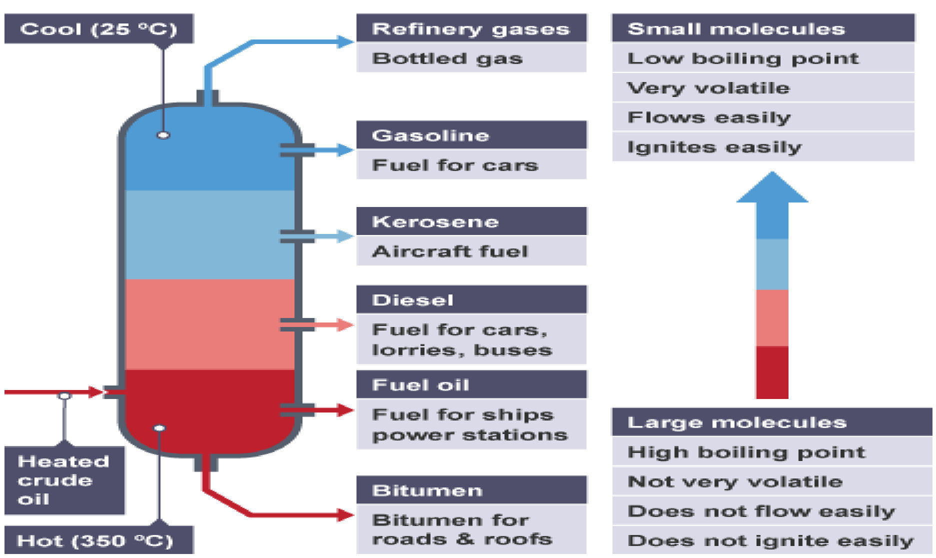
Fractional distillation

is the separation of a mixture into its component parts, or fractions. Chemical compounds are separated by heating them to a temperature at which one or more fractions of the mixture will vaporize. It uses distillation to fractionate. Generally the component parts have boiling points that differ by less than 25 °C (45 °F) from each other under a pressure of one atmosphere. If the difference in boiling points is greater than 25 °C, a simple distillation is typically used.

The two major types of distillation columns used are tray and packing columns.

Packing columns: are normally used for smaller towers and loads that are corrosive or temperature sensitive or for vacuum service where pressure drop is important.

Tray columns: on the other hand, are used for larger columns with high liquid loads. They first appeared on the scene in the 1820s. In most oil refinery operations, tray columns are mainly used for the separation of petroleum fractions at different stages of oil refining.



Fig(1) fractional distillation

How It Works

Vapors from a boiling solution are passed along a tall column, called a fractionating column. The column is packed with plastic or glass beads to improve the separation by providing more surface area for condensation and evaporation. The temperature of the column gradually decreases along its length. Components with a higher boiling point condense on the column and return to the solution; components with a lower boiling point (more volatile) pass through the column and are collected near the top.

Theoretically, having more beads or plates improves the separation, but adding plates also increases the time and energy required to complete a distillation.

	Simple distillation	fractional distillation
Uses	Separating relatively pure liquids that have large boiling point differences. Also separating liquids from solid impurities.	Isolating components of complex mixtures with small boiling point differences.
Advantages	Faster Requires less energy input Simpler, less expensive equipment	Better separation of liquids Better at purifying liquids containing many different components
Disadvantages	Only useful for relatively pure liquids Requires a large boiling point difference between components Doesn't separate fractions as cleanly	Slower Requires more energy More complicated and expensive setup

Fraction:

There are several ways of classifying the useful fractions that are distilled from crude oil. One general way is by dividing into three categories: light, middle, and heavy fractions. Heavier components condense at higher temperatures and are removed at the bottom of the column. The lighter fractions are able to rise higher in the column before they are cooled to their condensing temperature, allowing them to be removed at slightly higher levels. In addition to this, the fractions have the following properties:

- **Light distillate** is one of the more important fractions, and its products have boiling points around 70-200°C. Useful hydrocarbons in this range include gasoline, naphtha (a chemical feedstock), kerosene, jet fuel, and paraffin. These products are highly volatile, have small molecules, have low boiling points, flow easily, and ignite easily.
- **Medium distillate**s are products that have boiling points of 200-350°C. Products in this range include diesel fuel and gas oil - used in the manufacturing of town gas and for commercial heating.
- **Heavy distillate**s are the products with the lowest volatility and have boiling points above 350°C. These fractions can be solid or semi-solid and may need to be heated in order to flow. Fuel oil is produced in this fraction. These products have large molecules, a low volatility, flow poorly, and do not ignite easily

Crude oil stabilisation

Crude oil stabilisation

This chapter describes various processes used to stabilize a crude oil or condensate stream. Crude oil or condensate stabilization is the removal of light components from a hydrocarbon liquid to lower its vapor pressure to a desired level.

Why we used stabilization?

Stabilization may be used to meet a required pipeline sales contract specification or to minimize the vaporization of the hydrocarbon liquid stored in an atmospheric stock-tank. The stabilization process also results in reducing the amount of intermediate hydrocarbon components (propane and butane) that flash to the vapor state, increasing the liquid volume. Thus, it results in both increasing the liquid sales and decreasing the vapor pressure of the liquid. Various methods are used to remove the light components from hydrocarbon liquid, with the most common being stage separation before the oil enters a stock-tank or pipeline. Although separation followed by weathering in a stock-tank is not the most efficient method of stabilization, it is often the most economical method.

What is the products:

A stabilizer can achieve a stable specification product with a higher recovery, but with correspondingly higher capital investment and operating costs. Additional space is also required for a stabilizer. While this may not be a factor for onshore applications, it is often a major consideration for an offshore installation (or stabilization) is a partial distillation process that renders crude oil suitable for storage in atmospheric tanks, or of a quality suitable for sales or pipeline transportation. Stabilization is achieved by subjecting ‘live’ crude to temperature and pressure conditions in a fractionation vessel which drives off light hydrocarbons components to form a ‘dead’ or stabilized crude oil with a lower vapor pressure.

The stabilization process:

Live crude is heated in a furnace or heat exchanger to an elevated temperature.[3] The crude oil is fed to a stabilizer which is typically a tray or packed tower column that achieves a partial fractionation or distillation of the oil.[4] The heavier components, pentane (C_5H_{12}), hexane (C_6H_{14}), and higher hydrocarbons (C_7+), flow as liquid down through the column where the temperature is increasingly higher. At the bottom of the column, some of the liquid is withdrawn and circulated through a reboiler which adds heat to the tower.[4] Here the lighter fractions are finally driven off as a gas, which rises up through the column. At each tray or stage the rising gas strips the light ends from heavy ends, the rising gas becomes richer in the light components and leaner in the heavy ends.

Alternatively, if a finer separation is required the column may be provided with an upper section reflux system making it similar to a distillation column. As the reflux liquid flows down through the column it becomes leaner in light components and richer in heavy ends. Overhead gas from the stabilizer passes through a back pressure control valve that maintains the pressure in the stabilizer.

The stabilised crude oil, comprising pentane and higher hydrocarbons (C_5+), is drawn from the base of the stabilizer and is cooled. This may be by heat exchange with the incoming live crude and by cooling water in a heat exchanger. The dead, stabilized crude flows to tanks for storage or to a pipeline for transport to customers such as an oil refinery.[3] [4] [7]

The stabilization tower may typically operate at approximately 50 to 200 psig (345 – 1378 kPa).[5] Where the crude oil contains high levels of hydrogen sulphide (H_2S) a sour stabilization is undertaken. This entails operating the stabilizer at the lower end of the pressure range, whereas sweet (low H_2S) stabilization would take place at a higher pressure.[5]

Gas processing

The light hydrocarbons stripped from the crude are usually processed to yield useful products. Gas from the top of the stabilizer column is compressed and fed to a de-methanizer column. This column separates the lightest hydrocarbons, methane (CH_4) and ethane (C_2H_6), from the heavier components. Methane and ethane are withdrawn from the top of the column and are used as fuel gas in the plant, excess gas may be flared.

Liquid from the base of the de-methanizer is routed to the de-ethanizer. Gas from the top is principally ethane and is compressed and returned to the de-methanizer.

Liquid from the base of the de-ethanizer is routed to the de-propanizer. Gas from the top is principally propane (C_3H_8) and is compressed or chilled for storage and sales.

Liquid from the base of the de-propanizer is principally butane (C_4H_{10}) and some heavier components. Butane is stored and sold#3 and the heavier fraction sold or spiked into the stabilized crude.