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 sulfur, oxygen, nitrogen and metals such as vanadium, nickel, iron and copper are also present (See Table below).

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

Physical and Chemical Properties of Crude Oil and Oil Products

1. Density, Specific Gravity, and API Gravity

Density is defined as mass per unit volume of a fluid. Density is a state function and for a pure compound depends on both temperature and pressure and is shown by ρ. Liquid densities decrease as temperature increases.

Liquid density for hydrocarbons is usually reported in terms of specific gravity (SG) or relative density defined as:

$$SG = \frac{density\ of\ liquid\ at\ temperature\ T}{density\ of\ water\ at\ temperature\ T}$$

Since the standard conditions adopted by the petroleum industry are 60°F (15.5°C) and 1 atm, specific gravities of liquid hydrocarbons are normally reported at these conditions. Water density at 60°F is 0.999 or almost 1 g/cm3, thus:

$$\text{SG (60°F/60°F)} = \frac{\text{density of liquid at 60°F in g/cm}^3}{0.999\ \text{g/cm}^3}$$

The American Petroleum Institute (API) defined the API gravity (degrees API) to quantify the quality of petroleum products and crude oils. The API gravity is defined as:

$$API^{o} = 141.5/(\text{specific gravity}) - 131.5$$

A higher API gravity indicates a lighter crude or oil product, whereas a low API gravity implies a heavy crude or product. Therefore, crude oil with high values of API gravity are expensive to procure due to their quality. Crude oils can generally be classified according to API as shown:

Crude Category	Gravity
Light crudes	API > 38
Medium crudes	38 > API > 29
Heavy crudes	29 > API > 8.5
Very heavy crudes	API < 8.5

The definition of specific gravity for gases is somewhat different. The specific gravity of a gas is proportional to the ratio of molecular weight of gas (Mg) to the molecular weight of air (28.97).

$$\text{SG} = \frac{Mg}{28.97}$$

2. Viscosity

The viscosity of oil is a measure of its resistance to internal flow and an indication of its oiliness in the lubrication of surfaces. There are two types of viscosity: dynamic and kinematics viscosity.

$$\text{Kinematic viscosity } (\upsilon) = \text{dynamic viscosity } (\mu) / \text{density } (\rho)$$

The unit of dynamic viscosity is poise (0.1 Pa·s). It is more commonly expressed, particularly in ASTM standards, as centipoises (cP). While the kinematics viscosity as centiStokes -cSt ($10^{-6}m^2 \cdot s^{-1}$).

3. Pour Point

The pour point of a liquid is the temperature below which the liquid loses its flow characteristics. It is defined as the lowest temperature at which the sample will flow and is a rough indicator of the relative paraffinicity and aromaticity of the crude. A lower pour point means that the paraffin content is low and greater content of aromatics.

4. Flash, Fire and Auto Ignition Point

Flash and fire point are important parameter for safety considerations, especially during storage and transportation of volatile petroleum products (i.e., LPG, light naphtha, gasoline) in a high-temperature environment.

Flash Point (TF): The temperature at which the vapors produced from a fluid will ignite with the presence of an ignition source . Generally flash point increases with an increase in boiling point. The lowest temperature at which the fire will keep burning if ignited by an outside ignition source.is the **fire point**. Fire point is the temperature well above the flash point where the product could catch fire.

Auto Ignition is the minimum temperature at which a fluid will spontaneously ignite without an external ignition source, such as a flame or spark.

5. Sulfur Content, wt%

Sulfur content and API gravity are two properties which have had the greatest influence on the value of crude oil. The sulfur content is expressed as percent sulfur by weight and varies from less than 0.1% to greater than 5%. Crudes with greater than 0.5% sulfur generally require more extensive processing than those with lower sulfur content.

6. Salt Content, lb/1000 bbl

Salt content is typically expressed as pounds of salt (sodium chloride, NaCl) per 1000 barrels of oil (bbl). Salts in crude oil and in heavier products may create serious corrosion problems, especially in the top-tower zone and the overhead condensers in distillation columns. If the salt content of the crude is greater than 10 lb/1000 bbl, it is generally necessary to desalt the crude before processing.

7. Nitrogen

It is the weight of total nitrogen determined in a liquid hydrocarbon sample (in parts per million). Nitrogen compounds contribute negatively to process catalysts.

8. Ash content

Ash content is an indication of the contents of metal and salts present in a sample. The ash is usually in the form of metal oxides, stable salts, and silicon oxides. The crude sample is usually burned in an atmosphere of air and the ash is the material left unburned.

Types of Crude Oil

Heavy Crude

Heavy crude has API gravity lower than 28. The lower the API gravity, the heavier the oil should be. It usually contains high concentrations of sulfur and several metals, particularly nickel and vanadium (high amount of wax). These are the properties that make them difficult to pump out of the ground or through a pipeline and interfere with refining. These properties also present serious environmental challenges to the growth of heavy oil production and use.

Light Crude

Light crude has API gravity higher than 38. The higher the API gravity, the lighter the crude oil shall be. Light crude is defined as having a low concentration of wax. This classification of oil is easier to pump and transport.

Sweet Crude

Sweet crude has small amounts of hydrogen sulfide and carbon dioxide, and is used primarily in gasoline. Sweet crude is usually a crude oil that has a sulfur content that is 0.5% or less by weight. Lower sulfur content improves the quality of the resulting refined products, and sweet crudes do not require as much processing as sour crudes. They are referred to as sweet because of the absence of an unpleasant sulfur smell.

Sour Crude

Usually crude oil that has a sulfur content that is greater than 0.5% is considered sour. This higher sulfur content affects the quality of the resulting refined products and sometimes means extra processing is required. It is referred to as sour because of the unpleasant smell of the sulfur.

Pre-Treatment of Oil at Oil Field before Refining

Oil and gas when they come out of oil field are separated. The natural gas is compressed to liquify it which is used for heating of domestic and industrial ovens. Petroleum oil is made free of :

- Water,
- Sediments and
- Salts present in it.

It is then made free of some dissolved gases into it by the process called 'stabilisation'. It is then sent to oil refinery _ for separation into various petroleum products by distillation mainly and auxiliary operations.

Crude oil as it comes out of well may contain up to 25% water, salts ($MgCl_2$,-$CaCl_2$, NaCI etc.) up to 2000-5000 (mg/liter) and sediments up to 1-1.5%. For refining crude oil, the salt content in it should be < 50 mg/liter and Water < 0.3%. Excessive water in crude requires extra heat for its distillation, increases its cost of transportation, forms emulsion which absorb materials like resin (hence emulsion breakers are to be used).

Salt in crude oil causes:

- scaling
- corrosion
- reduces heat transfer co-efficient during its processing.

Sediments present in crude causes:

- erosion
- scaling.

In mechanical method of separation of impurities from crude oil, it is subjected to centrifuging, filtration and settling after heating it to 120-160°C at 6-8 atm.pressure. In physico-chemical method, emulsion breakers are added. But they are costly and cause corrosion & sludge formation.

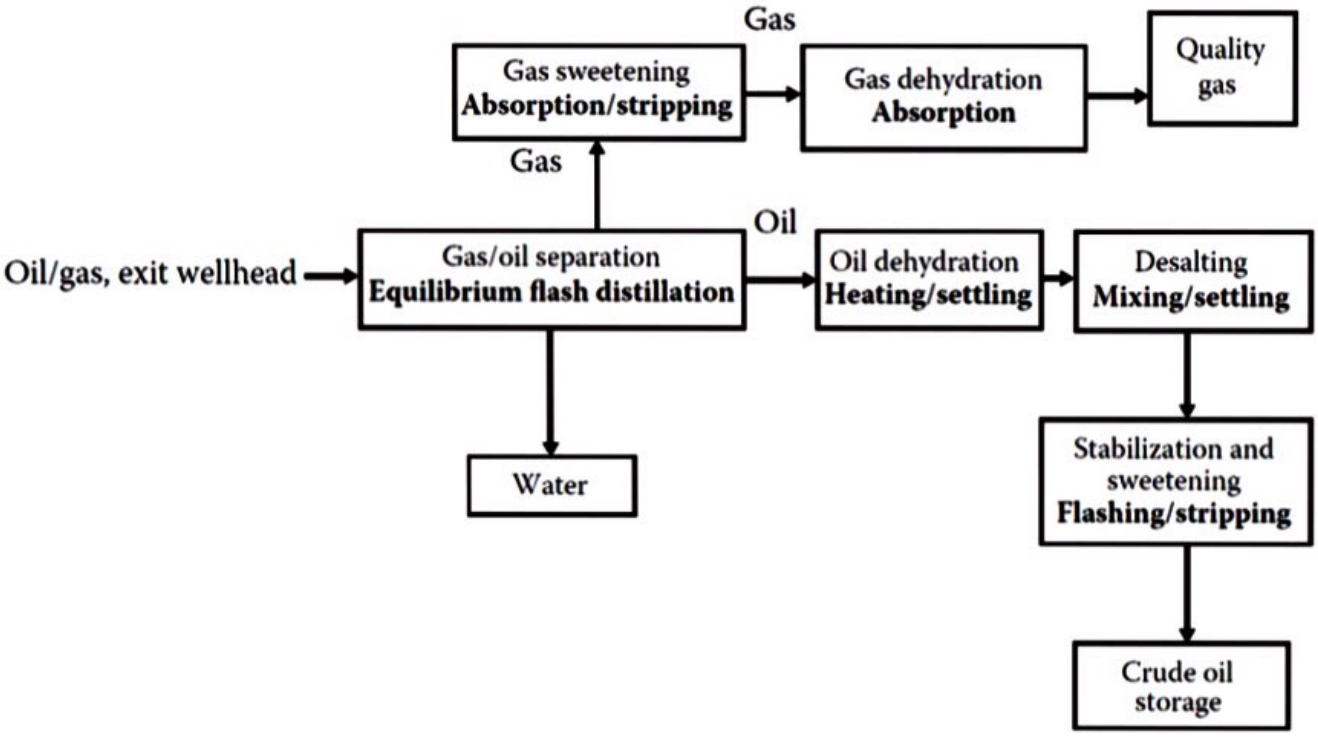

Figure 2-1. Flow-sheet of industrial pre-treatment unit of crude oil and gas