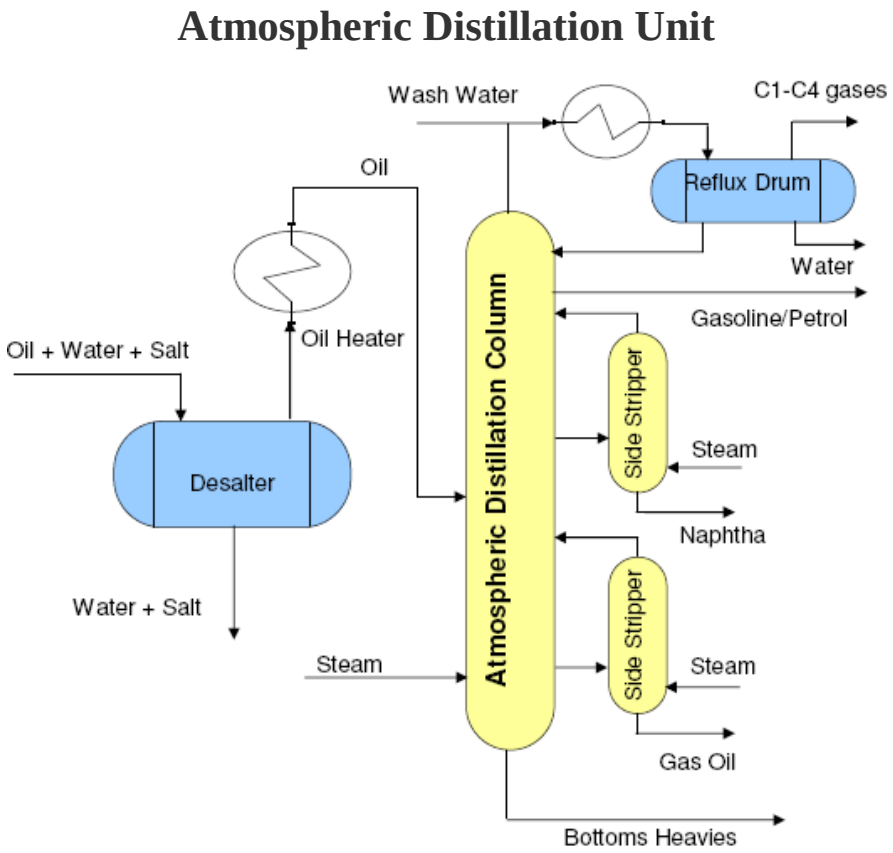

Figure 1 – Typical PFD for an Atmospheric Distillation Unit

Crude oil is sent to the **Atmospheric distillation unit** after desalting and heating.

The purpose of atmospheric distillation is primary separation of various «cuts» of hydrocarbons namely, fuel gases, LPG, naphtha, kerosene, diesel and fuel oil.

The heavy hydrocarbon residue left at the bottom of the atmospheric distillation column is sent to vacuum distillation column for further separation of hydrocarbons under reduced pressure.

As the name suggests, the pressure profile in atmospheric distillation unit is close to the atmospheric pressure with highest pressure at the bottom stage which gradually drops down till the top stage of the column.

The temperature is highest at the bottom of the column which is constantly fed with heat from bottoms **reboiler**.

The **reboiler** vaporizes part of the bottom outlet from the column and this vapor is recycled back to the distillation column and travels to the top stage absorbing lighter hydrocarbons from the counter current crude oil flow.

The temperature at the top of the column is the lowest as the heat at this stage of the column is absorbed by a **condenser** which condenses a fraction of the vapors from column overhead.

The condensed hydrocarbon liquid is recycled back to the column. This condensed liquid flows down through the series of column **trays**, flowing counter current to the hot vapors coming from bottom and condensing some of those vapors along the way.

Thus a reboiler at the bottom and a condenser at the top along with a number of trays in between help to create temperature and pressure gradients along the stages of the column.

The gradual variation of temperature and pressure from one stage to another and considerable residence time for vapors and liquid at a tray help to create near **equilibrium conditions at each tray**.

So ideally we can have a number of different vapor-liquid equilibria at different stages of this column with varying temperature and pressure conditions. This means that the hydrocarbon composition also varies for different trays with the variation in temperature and pressure.

The **heaviest hydrocarbons** are taken out as liquid flow from the **partial reboiler at bottom** and the **lightest hydrocarbons** are taken out from the **partial condenser at the column overhead**.

Various other cuts of hydrocarbons are taken out as **side draws** from different stages of the column. Starting from LPG at the top stages, naphtha, kerosene, diesel and gas oil cuts are taken out as we move down the stages of atmospheric column.

The heaviest hydrocarbon residue taken out from partial reboiler is sent to the Vacuum distillation column for further separation under reduced pressure.

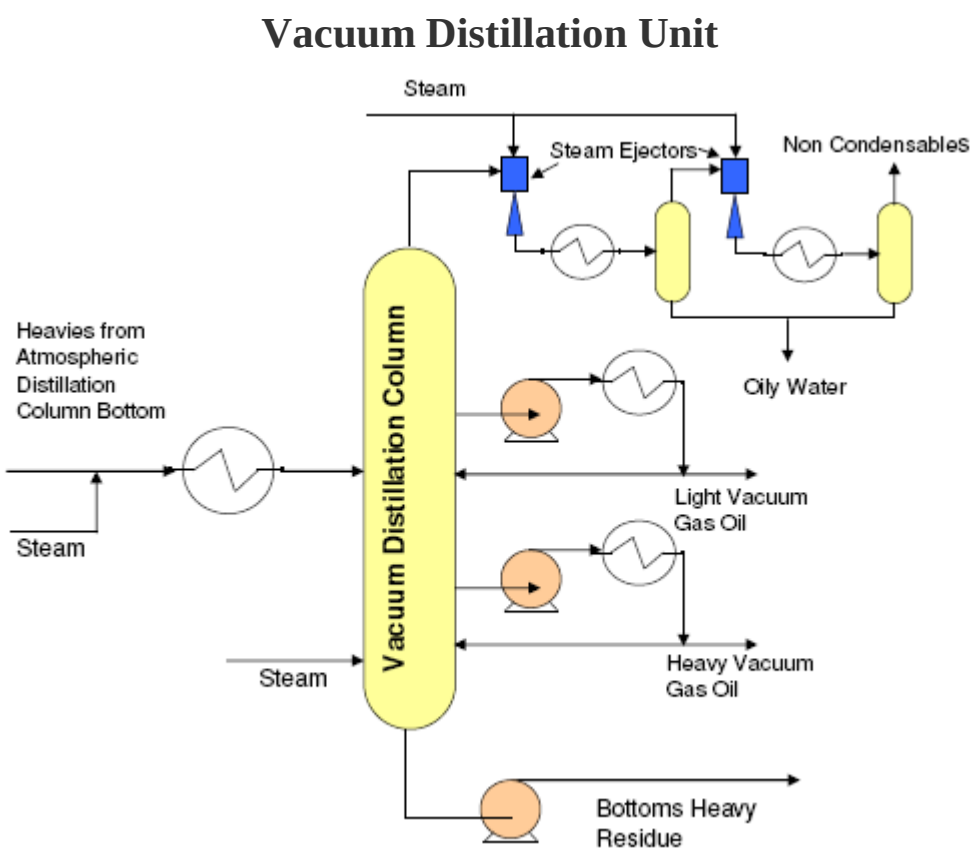

Figure 1 – Typical PFD of a Vacuum Distillation Unit

Heavies from the Atmospheric distillation column are heated to approximately 400˚C in a fired heater and fed to the **Vacuum distillation column** where they are fractionated into **light vacuum gas oil (LVGO)**, **heavy vacuum gas oil (HVGO)** and **vacuum residue**.

Unit 5. Crude oil distillation. **Lecture.**

Some heavy hydrocarbons cannot be boiled at the operating temperature and pressure conditions in the atmospheric distillation column. Hence they exit the bottom of the column in liquid state and are sent to the vacuum distillation column where they can be boiled at a lower temperature when pressure is significantly reduced.

Absolute operating pressure in a vacuum tower can be reduced to 20 mm of Hg or less (atmospheric pressure is 760 mm Hg).

In addition, superheated **steam** is injected with the feed and in the tower bottom to reduce hydrocarbon partial pressure to 10 mm Hg or less. Lower partial pressure of the hydrocarbons makes it even easier for them to be vaporized, thus consuming less heat energy for the process.

Steam ejectors can be used to suck the lighter hydrocarbon vapors at low pressure from the top of the column. These vapors are then cooled down to condense the steam which had been introduced in the column earlier. The condensed **oily water** is removed and can be recycled to the column after boiling it. Hydrocarbon vapors are taken out at this stage.

Two different cuts of hydrocarbons – **«light vacuum gas oil»** and **«heavy vacuum gas oil»** are separated in the vacuum distillation column at different stages of the column, based on the difference between their boiling point ranges.

The liquid being drawn at low pressure needs to be pumped. Then it is heated and partially recycled back to the column.

Light vacuum gas Oil is sent to a **hydrotreater** and then to a **catalytic cracking unit** to obtain smaller chain hydrocarbons. **Heavy vacuum gas oil** is also sent for cracking using hydrogen in a **hydrocracking unit** to produce smaller chain hydrocarbons.

Heavy hydrocarbons which cannot be boiled even under reduced pressure remain at the bottom of the column and are pumped out as **vacuum residue**. The vacuum distillation column bottom residue can only be used for producing **coke** in a **coker unit** or to produce **bitumen**.