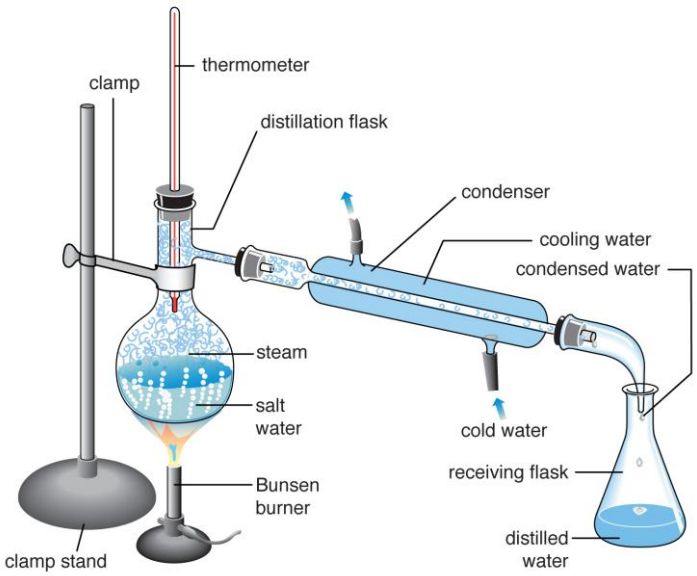
ASTM distillation curves of petroleum products

- **Distillation is the process** of separating the component or substance of a liquid mixture by selective evaporation and condensation depending on their differences in the volatility or boiling point.
- **Volatility** is the tendency of a substance to vaporize. Volatility is directly related to a substance's vapour pressure.
- At a given temperature, a substance with higher vapour pressure vaporizes more readily than a substance with a lower vapour pressure.
- For distillates (gasoline, kerosene, diesel and heating oil) the distillation is run at atmospheric pressure ASTM D86 test.

ASTM D86 distillation apparatus consisting of:

- flask holding the sample **(100 ml)** connected to an **inclined condenser**, which condensed the rising vapour. The fractions distilled are collected in a **graduated cylinder**.
- The temperature at which the **first drop** of condensate is collected is called the **initial boiling point (IBP).**
- The **end point (EP)** is the **last drop** of condensate collected, which is the maximum vapour temperature when almost the entire sample is distilled.



ASTM D86 simple atmospheric distillation apparatus

For a petroleum fractions of unknown composition, the boiling point may be presented by a curve of temperature versus vol% (or fraction) of mixture vaporized based on 100 units of volume.

Vol %	**IBP**	**T5**	**T10**	**T30**	**T50**	**T70**	**T90**	**T95**	**FBP**
ASTM D86 °C									
% Recovery or total distillate TD:									
% Residue: **% Loss:**									

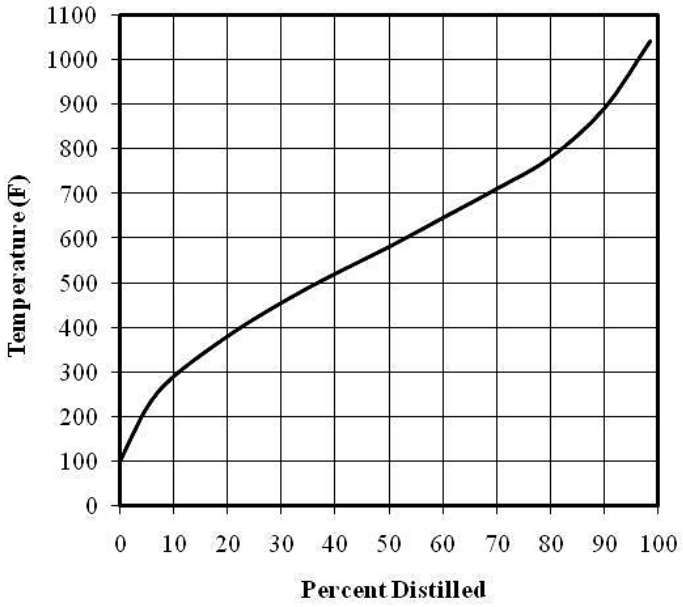


Figure (5): distillation curve

Exercise: The ASTM D86 data for finished petroleum fraction having specific gravity of 0.720 at 60/60 °F is shown below**. Answer the following:**

a)Calculate VABP, also find MeABP and WABP.

b)Find the molecular weight of the fraction and compare with the value obtained from Figure 2.

c)Find the base of the fraction.

d)Give suitable name for the fraction.

Vol % distilled	**IBP**	**5**	**10**	**30**	**50**	**70**	**90**	**95**	**EP**
ASTM D86 °C	**37**	**42**	**49**	**66**	**93**	**133**	**203**	**211**	**217**

Answer:

a)

$$VABP = \frac{120.2 + 150.8 + 199.4 + 271.4 + 397.4}{5} = 227.84\ °F$$

$$SL = \frac{397.4 - 120.2}{90 - 10} = 3.465°F$$

Refer to Figure 4

$$MeABP = 227.84°F - 25°F = 203.84°F$$

$$WABP = 227.84°F + 10°F = 238.84°F$$

b)

$$\boldsymbol{Tb = \frac{T30 + T50 + T70}{3} = \frac{66 + 93 + 133}{3} = 97.33℃ = 370.48\ K}$$

$$\boldsymbol{M =}$$

$$\boldsymbol{42.965[\exp(2.097\ x\ 10^{-4}\ T_b - 7.7812SG + 2.08476\ x\ 10^{-3}\ T_bSG)]T_b^{1.26007}SG^{4.98308} = 100.264}$$

The **API 65**. Using Figure (2) and the MeABP obtained from Figure (4), a molecular weight of 100 is read off.

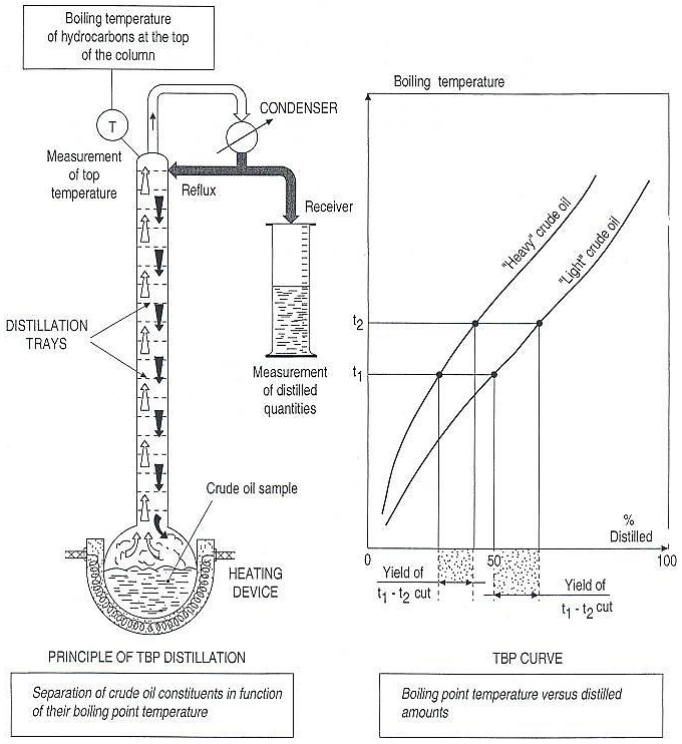
c)

$$\boldsymbol{kw = \frac{\sqrt[3]{MeABP\ R}}{SG} = 12.11\ paraffinic\ base}$$

d) The name of the fraction is Gasoline

True Boiling Point Distillation curve TBP (ASTM D2892)

- Data from TBP distillation provides more detailed characterization of the volatility of crude oil or petroleum fraction.
- It is performed in columns with **15 theoretical plates** or equilibrium stages and a **reflux ratio** of **5:1**.
- Because the **high degree of separation** for TBP, the **IBP is lower and EP is higher** than those of the **ASTM D86 test**.



TBP apparatus

After constructing the TBP distillation curve, the amount of different cuts that can be produced from atmospheric distillation of crude oil can be calculated based on their initial and end boiling point.

Example: Consider the TBP curve for crude oil. Find the volumetric range (vol %), mid boiling points and API, and Kw for the naphtha, kerosene, diesel, AGO, lube oil, and residue cuts using Figure (6).

Vol % distilled	T0	T10	T20	T30	T40	T50	T60	T70	T80	T100
TBP °F	200	270	335	400	480	560	610	680	820	1100

Answer:

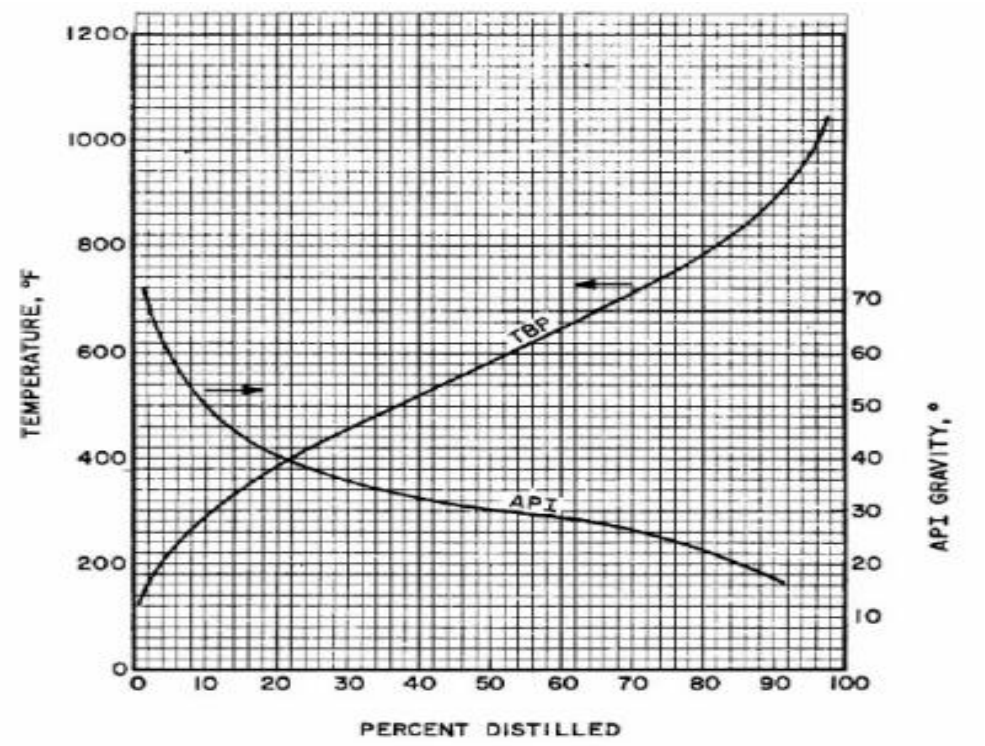


Figure (6): TBP and gravity-mid-percent curves

***Naphtha cut*: 200 − 400°F**

$Volumetric\ range\ \% = 4 - 22\ \% =$ **18% *vol***

$mid\ B.P = \left(4 + \frac{18}{2}\right) = 13\%$ $at\ 13\%\ mid\ B.P = 320°F$ $API = 46$ $Kw = 11.65$

***Kerosene cut*: 400 − 480°F**

$Volumetric\ range\ \% = 22 - 34\ \% =$ **12% *vol***

$mid\ B.P = \left(22 + \frac{12}{2}\right) = 28\%$ $at\ 28\%\ mid\ B.P = 440°F$ $API = 36$ $Kw = 11.43$

***Diesel cut*: 480 − 610°F**

$Volumetric\ range\ \% = 34 - 54\ \% =$ **20% *vol***

$mid\ B.P = \left(34 + \frac{20}{2}\right) = 44\%$ $at\ 44\%\ mid\ B.P = 540°F$ $API = 32$ $Kw = 11.540$

***AGO cut*: 610 − 680°F**

$Volumetric\ range\ \% = 54 - 64\ \% =$ **10% *vol***

$mid\ B.P = \left(54 + \frac{10}{2}\right) = 59\%$ $at\ 59\%\ mid\ B.P = 640°F$ $API = 29$ $Kw = 11.71$

***lube oil cut*: 680 − 820°F**

$Volumetric\ range\ \% = 64 - 84\ \% =$ **20% *vol***

$mid\ B.P = \left(64 + \frac{20}{2}\right) = 74\%$ $at\ 74\%\ mid\ B.P = 740°F$ $API = 25$ $Kw = 11.755$

***ATM residue*: 820 − 1100°F**

$Volumetric\ range\ \% = 84 - 100\ \% =$ **16% *vol***

$mid\ B.P = \left(84 + \frac{16}{2}\right) = 92\%$ $at\ 92\%\ mid\ B.P = 910°F$ $API = 16$ $Kw = 11.56$