

The Calculation and Examples of Crude Oil Distillation

Example 1: A petroleum cut has the following ASTM -D86 Distillation data:

Volume % distilled	0	10	30	50	70	90	95
Temperature (°C)	36.5	54	77	101.5	131	171	186.5

- (a). Convert these data to TBP data using the API method of (*Riazi and Daubert*) method.
(b). Plot the results and compare.

Ans.: (a) Start from equation (4.1) and **Table (4.3)** to obtund the TBP of this data:

$$T_{TBP} = a (T_{ASTMD86})^b \dots\dots\dots(4.1)$$

Table 4.3 constant of equation (4.1)

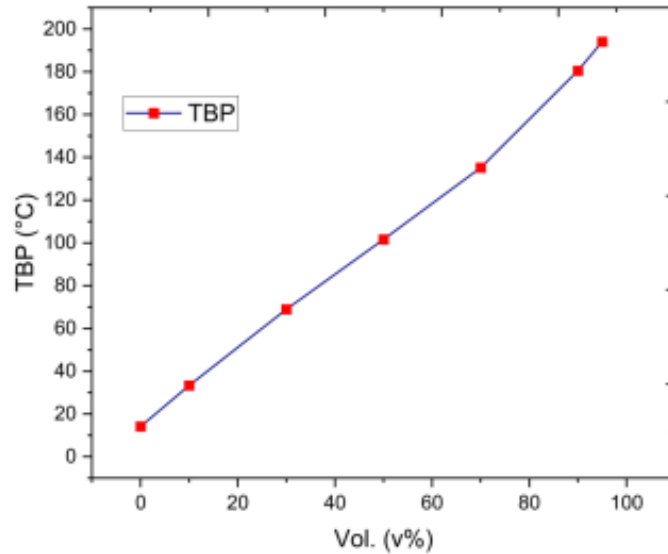
Volume % distilled	<i>a</i>	<i>b</i>
0	0.9167	1.0019
10	0.5277	1.0900
30	0.7429	1.0425
50	0.8920	1.0176
70	0.8705	1.0226
90	0.9490	1.0110
95	0.8008	1.0355

Must be converted to the Temp. from (°C) to (°R)

$$T_{(R)} = T_{(C)} * (9/5) + 491.67$$

Vol.(v%)	T (°C) by ASTM-D86	T (°R)	API method (Raizi method) by Eq.(4.1)			
			<i>a</i>	<i>b</i>	T _{TBP} (°R)	T _{TBP} (°C)
0	36.5	557.37	0.9167	1.0019	517.1166	14.13701
10	54	588.87	0.5277	1.09	551.7067	33.35373
30	77	630.27	0.7429	1.0425	615.796	68.9589
50	101.5	674.37	0.892	1.0176	674.6083	101.6324
70	131	727.47	0.8705	1.0226	734.9552	135.1585
90	171	799.47	0.949	1.011	816.5809	180.506
95	186.5	827.37	0.8008	1.0355	841.012	194.0789

(b) Plot the results and compare.



Example 2: A petroleum cut has the following ASTM D86 Distillation data in the example1, calculate :

- a) **MeABP** of the petroleum fraction if the API gravity of this fraction is 62.
- b) **Watson's characterization factor K.**

Ans.: a) The first step convert the temperature from °C to °F :

$$T (°F) = (T (°C) * 1.8) + 32$$

Temp. (°C)	36.5	54	77	101.5	131	171	186.5
Temp. (°F)	97.7	129.2	170.6	214.7	267.8	339.8	367.7

$$VABP = \frac{T_{10} + T_{30} + T_{50} + T_{70} + T_{90}}{5} \dots\dots\dots(4.3)$$

$$VABP = (129.2+170.6+214.7+267.8+339.8) / 5$$

$$VABP = 224.42 \text{ } ^\circ\text{F}$$

$$SL = \frac{T_{90}-T_{10}}{90-10} \dots\dots\dots(4.7a)$$

$$SL = (339.8 - 129.2) / (90 - 10)$$

$$SL = 2.632$$

$$\ln \Delta = -0.94402 - 0.00865(VABP - 32)^{0.6667} + 2.99791 SL^{0.333} \dots(4.7a)$$

$$\Delta = 18.278$$

$$MeABP = VABP - \Delta \dots(4.7)$$

$$MeABP = 224.42 - 18.278$$

$$MeABP = 206.14 \text{ } ^\circ\text{F}$$

b) Watson's characterization factor K

$$K = \frac{\sqrt[3]{\text{Mean average boiling points (MeABP)}}}{SG}$$

$$S.G = 141.5 / (\text{API} + 131.5) = 0.7312$$

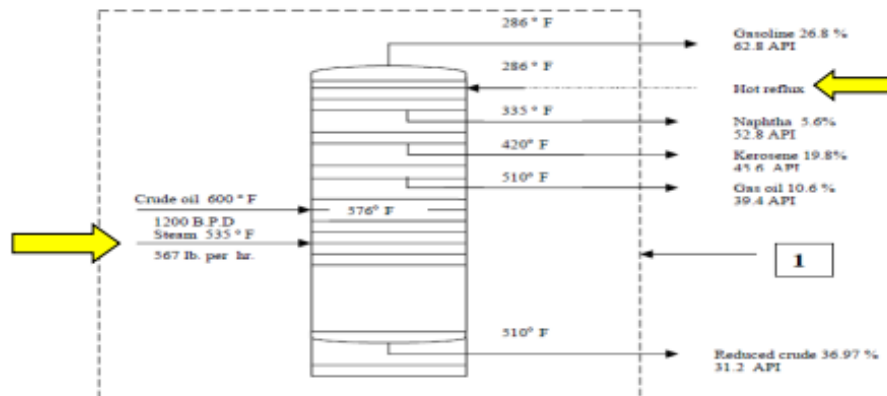
$$K = (666.1414)^{0.3333} / 0.7312$$

$$K = 11.94$$

Example 3 Heat Balance of a Fractionating Tower

A heat balance of the simple tower system shown in Fig. below will be computed to determine the amount of heat that must be removed to keep the tower in thermal balance. The capacity is 1200 bbl per day (2100 gal per hour) of a 12.1 to 12.2 Characterization Factor crude oil. At 576 °F, the gasoline, naphtha, kerosene, and gas oils are vapour and the reduced crude oil is a liquid. A sufficient quantity of heat must be removed from the vapours to cool them as vapours to the temperature at which they are withdrawn from the tower and to condense the naphtha, kerosene, and gas oil at their:

	Volume, Percent	API	Lb per gal	Gal per hr	Lb per hr	50 per cent bp	Mol. wt	Latent heat
Gasoline	26.8	62.8	6.06	563	3415	260	110	120
Naphtha	5.63	52.8	6.39	118	754	370	155	113
Kerosene	19.8	45.6	6.65	416	2765	460	185	100
Gas oil	10.6	39.4	6.89	222	1530	585	240	90
Reduced crude	36.97	31.2	7.24	776	5610			
Loss	0.2				96			
Crude	100.00	43.0	6.75	2100	14170			



Ans.:Energy Balance Basis = 1h

By using the information from the table and figure in example 3

a. Calculated the sensible heat

Materials (vapour)	mass per hour (lb.h ⁻¹)	Cp (J.K ⁻¹)	Δ T(°F)	Q _s =mcpΔT (Btu)
Gasoline	3415	0.56	576-286	589,000
Naphtha	754	0.55	576-335	106,000
Kerosene	2765	0.57	576-420	261,000
Gas oil	1530	0.59	576-510	63,000
Reduced crude	5610	0.72	576-510	276,000
Total				1,295,000

Q_s of stem inlet of tower

$$Q(\text{stem}) = m \text{ cp } \Delta T = 567 * 0.5 * (535-286) = 70,600$$

For Total heat balance = 1,295,000 + 70,600 = 1,365,000 Btu.

b. Calculate the latent heat:

Materials (vapour)	mass per hour (lb.h ⁻¹)	λ (Btu/lb)	Q _l =mλ (Btu)
Naphtha	754	113	85,100
Kerosene	2765	100	276,500
Gas oil	1530	90	138,000
Total heat to be removed			1,865,200