1. Petroleum refinery

Petroleum refinery is an industrial process plant where crude oil is transformed and refined into more useful products such as petroleum naphtha , gasoline , kerosene , diesel fuel ,asphalt base, and fuel oil. Petrochemicals feed stock like ethylene and propylene can also be produced directly by cracking crude oil without the need of using refined products of crude oil such as naphtha. Oil refineries are typically large, sprawling industrial complexes with extensive piping running throughout, carrying streams of fluids between large chemical processing units, such as distillation columns. In many ways, oil refineries use much of the technology, and can be thought of, as types of chemical plants. The crude oil feed stock has typically been processed by an oil production plant. There is usually an oil depot at or near an oil refinery for the storage of incoming crude oil feedstock as well as bulk liquid products.

2. Evaluation of crude oil

Characterization factor

$$K = \frac{\sqrt[3]{T_{av}}}{SG}$$

K: characterization factor

SG: specific gravity at 60 ºF

T_{av} : average boiling point in ºR

$$SG = \frac{141.5 - API}{131.5}$$

A crude oil assay is a compilation of laboratory (physical and chemical properties) and pilot - plant (distillation and product fractionation) data that characterize specific crude oil. Assay analyses of whole crude oils are carried out by combining atmospheric and vacuum distillation units, which when combined will provide a true boiling - point (TBP) distillation. These batch distillation methods, although taking between 3 and 5 days, allow the collection of a sufficient amount of distillation fractions for use in further testing.

In such instances, true boiling point (TBP) and gravity-mid percent curves can be developed from U.S. Bureau of Mines crude petroleum analysis data sheets.

The bureau of mines analysis is reported in two parts; the first is portion of distillation at atmospheric pressure and up to 527 ^oF , the second at 40 mm Hg total pressure to 572 ^oF end point.

Example

Calculate Watson characterization factor K for the whole crude oil, if you know that:

$K \geq 12.15$ paraffinic base
$11.5 \leq K \leq 12.15$ intermediate base
$K < 11.5$ naphthenic base

Fraction no.	Pressure mmHg	TBP Temp. °F	Vol.% distilled	Cumulative Vol.%	Mid Vol%	SG at 60 °F	API
1	760	122	0.8	0.8	0.4	0.673	78.8
2	760	167	1.0	1.8	1.3	0.685	75.1
3	760	212	3.0	4.8	3.3	0.725	63.7
4	760	257	3.4	8.2	6.5	0.755	55.9
5	760	302	3.1	11.3	9.75	0.777	50.8
6	760	347	3.9	15.2	13.25	0.798	45.8
7	760	392	4.9	20.1	17.65	0.817	41.7
8	760	437	6.8	26.9	23.5	0.833	38.4
9	760	482	8.0	34.9	30.9	0.848	35.4
10	760	527	10.9	45.8	40.35	0.864	32.3
11	40	392	7.3	53.1	49.45	0.873	30.6
12	40	437	7.8	60.9	57	0.879	29.5
13	40	482	6.2	67.1	64	0.889	27.7
14	40	527	5.7	72.8	69.95	0.901	25.6
15	40	572	6.9	97.7	76.25	0.916	28.0
Residuum	40	…	20.3	100.0	89.85	0.945	18.2

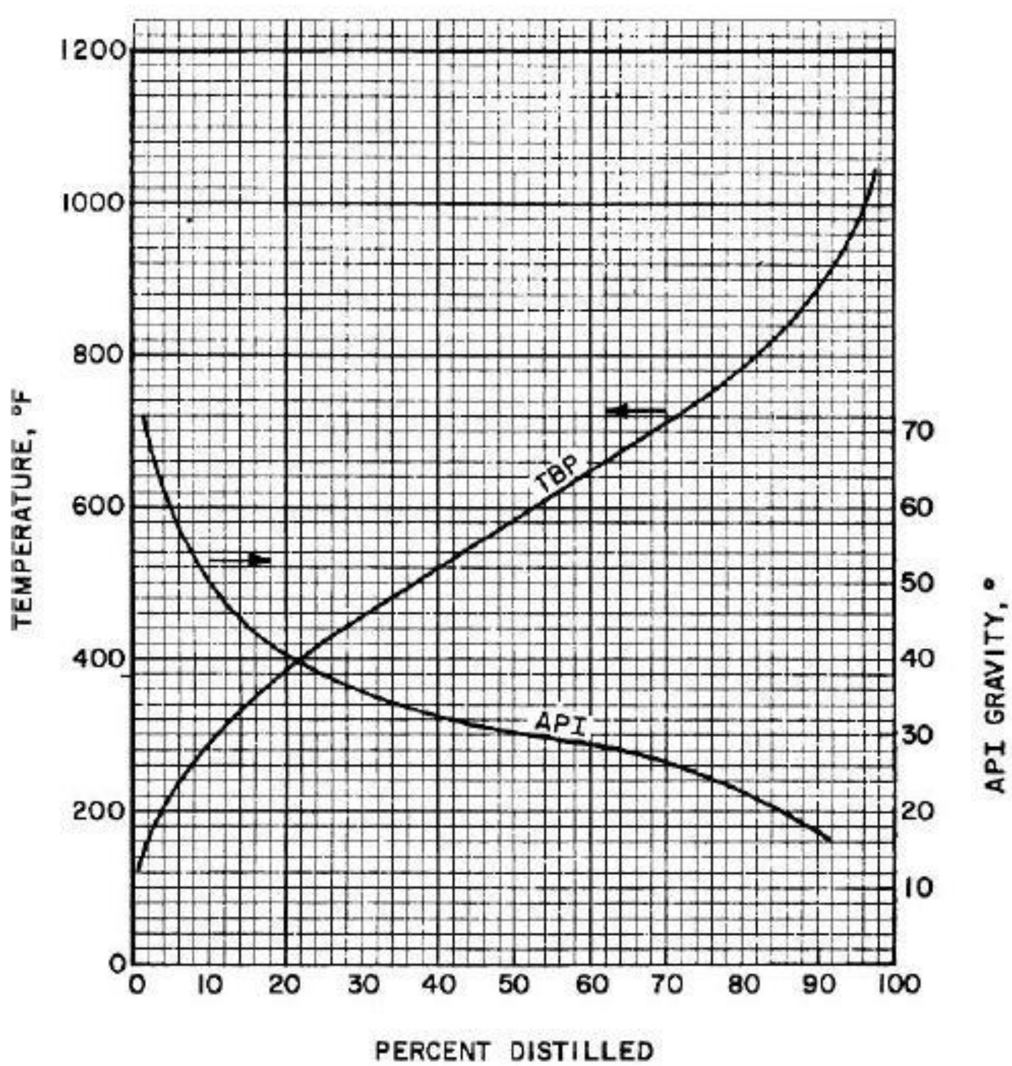
Step of solution:

1-calculte volume average boiling point TVABP (t 20, 50, and 80 from graph)

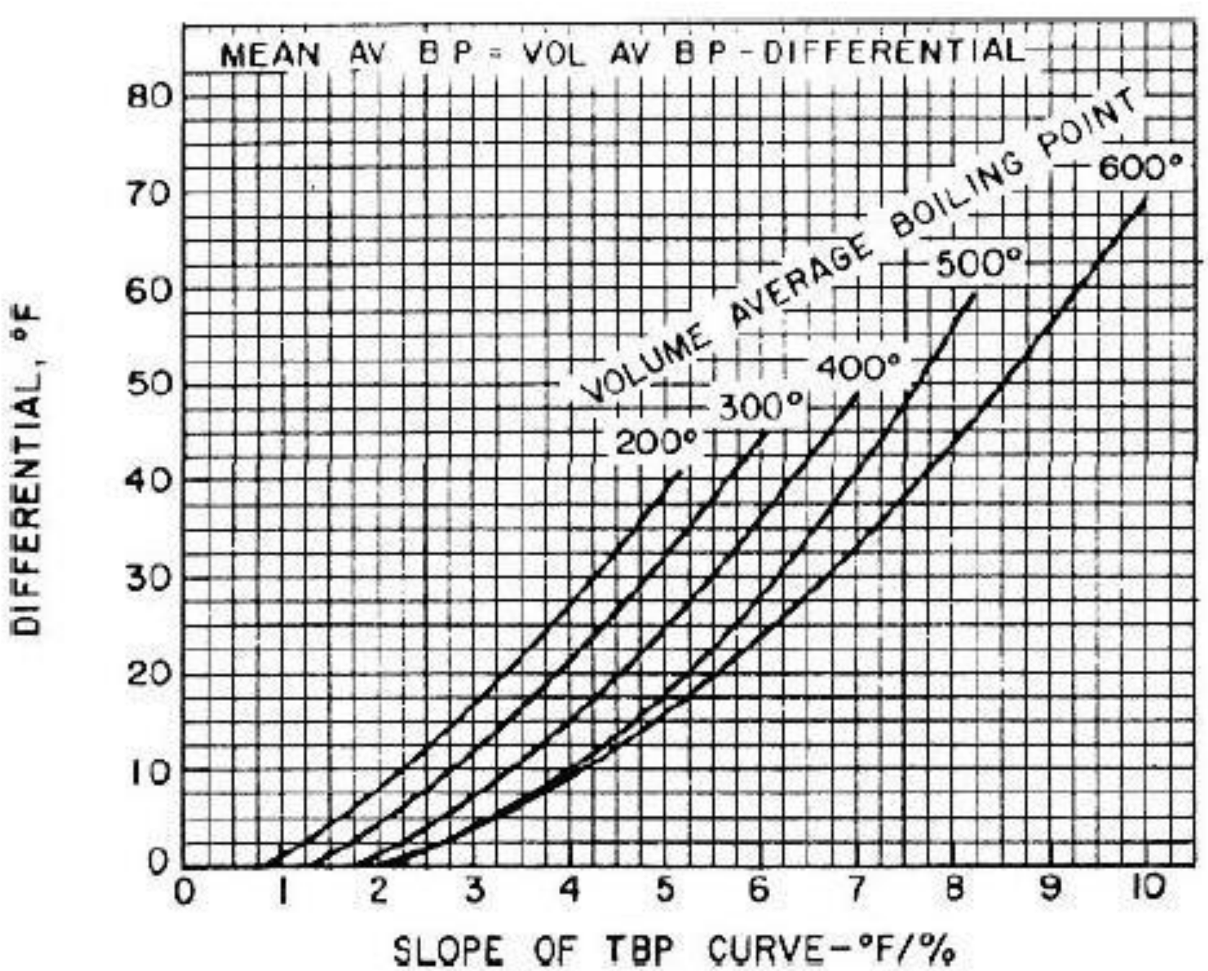
$$TVABP = \frac{t\,20 + t\,50 + t80}{3} = \frac{390 + 570 + 700}{3} = 483°\text{F}$$

2-calclate $t_{10\%}$ to $t_{70\ \%}$ slope

$$slope = \frac{t70 - t10}{60} = \frac{700 - 280}{60} = 7$$



3-find correction factor from the following chart



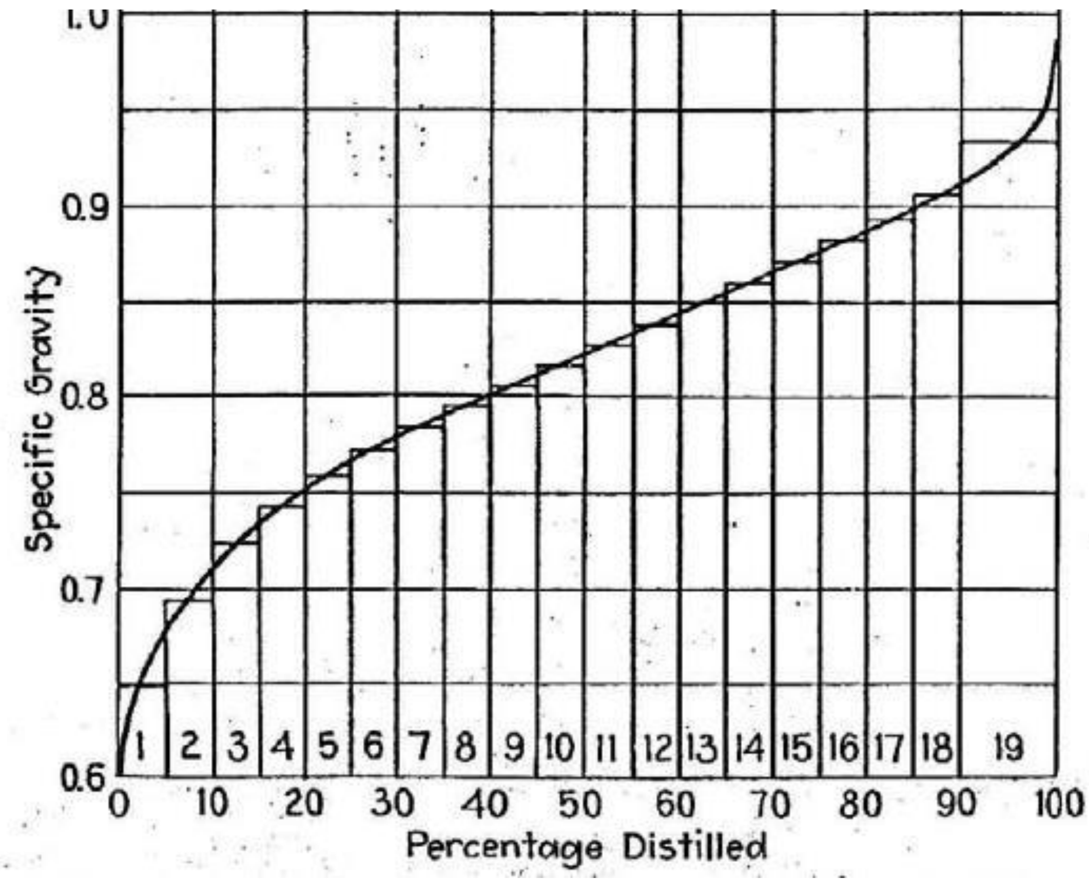
From the graph for slope =7 and volume average boiling point=483, we get Δt=43 ºF.

TMABP=TVABP - Δt =483-43 = 440 ºF.

4-constract a SG mid percent curve and evaluate the specific gravity for crude

Plot volume distilled percent and specific gravity (from table)

- Assume that curve is broken up to 19 fractions.
- The gravities of 19 materials are indicated by 19 short lines.



Fraction No.	Range of percentage	Sp gr	Fraction No:	Range of percentage	Sp gr
1	0–5	0.6506	11	50–55	0.8280
2	5–10	0.6936	12	55–60	0.8388
3	10–15	0.7227	13	60–65	0.8498
4	15–20	0.7420	14	65–70	0.8602
5	20–25	0.7583	15	70–75	0.8713
6	25–30	0.7720	16	75–80	0.8827
7	30–35	0.7844	17	80–85	0.8939
8	35–40	0.7958	18	85–90	0.9065
9	40–45	0.8067	19	90–100	0.9340
10	45–50	0.8170			

By inspecting the specific gravities

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The gravity of the crude is equal to 5 times specific gravities for each fraction 1-18 plus 10 times specific gravity for fraction 19 divided by 100.

$$SG = \frac{5\sum_{1}^{18} SG + 10SG_{19}}{100} = \frac{5(0.6506+0.6936+0.7227+\cdots)+10\times0.934}{100} = 0.8171$$

$$5\text{-}K = \frac{\sqrt[3]{440+460}}{0.867} = 11.13$$

K< 11.5 → The whole crude is naphthenic base.

However, the characterization factor is related to viscosity, aniline point, molecular weight, critical temperature of hydrocarbon etc.

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