

# Evaluation of Crude Oil

Evaluation of crude oil is important for refiner because it gives the following types of information:

1. Base and general properties of the crude oil.
2. Presence of impurities such as sulfur, salt, and emulsions which cause general difficulties in processing.
3. Operating or design data. Primarily this necessitates curves of temperature and gravity vs. per cent distilled.
  - a. Fractionating or true boiling point distillation curve.
  - b. Equilibrium or flash-vaporization curve.
  - c. API or specific gravity curve of each fraction distilled.
4. Curves of the properties of the fractions vs. percent distilled (mid per cent curves) or the average properties of a series of fractions vs. Percentage yield (yield curve) by which common realization of yields can be prepared. Among property curves are
  - a. Viscosity of lubricating-oil fractions
  - b. Octane number of gasoline fractions.
  - c. Aniline point of solvents, kerosene, or diesel fractions.
  - d. Percentage of asphaltic residues.
  - e. Viscosity of distillation residues.

5. Finished products. Having established the general properties and yield by means of distillation and property curves and exploring the economy of the various break-ups of the crude oil.

## **Base of crude oil**

1) Mallison classification according to residuum: ( a material left behind after distillation of fractions.)

<b>Residue &gt; 50% paraffins</b>	<b>Paraffinic base</b>
Residue < 20% paraffins	Asphaltic base
Residue 20-50% paraffins	Mixed base

## 2)The U.S. Bureau of Mines designated eight base of crude oil

Key Fraction	Boiling point	Pressure	API	Note
No. 1	482-527	atm.	> 40 (Paraffinic Base) 33<API >40 (Intermediate Base) API < 33 (Naphthene Base)	
No. 2	527-572 733-779	(40-mm)Hg 1 atm	> 30 (Paraffinic Base) API < 22 (Naphthene Base) 22<API<30 (Intermediate Base)	The presence of wax is noted by cloud point (if below ) it indicates little wax (Wax-free)

### 3) Specific Gravity and API Gravity:

Specific gravity and API (American Petroleum Institute) gravity are expressions of the density or weight of a unit volume of material. The specific gravity is the ratio of the weight of a unit volume of oil to the weight of the same volume of water at a standard; both specific gravity and API gravity refer to these constants at 60 °F(16 ° C).

$$API = \frac{141.5}{Sp.gr.} - 131.5 \quad \text{or} \quad Sp.gr. = \frac{141.5}{API + 131.5}$$

Corresponding values of API gravity (0 to 100)

#### 4) Characterization Factor: (C.F), (K)

The most widely used index is characterization factor (Watson, Nelson and Murphy).

It was originally defined as:

$$K = \frac{\sqrt[3]{T_B}}{S}$$

In which:

TB is the average molal boiling point ( R)

S: is the specific gravity at 60 °F

It has since related to viscosity, aniline, temperature, molecular weight, critical temperature, percentage of hydrocarbon etc.

$K \geq 12.15$  (Paraffinic Base)

$K < 11.5$  (Naphthene Base)

$K$  between 11.5-12.15 (Intermediate Base)

### 5) Correlation Index: (C.I)

Like (C.F) related to boiling point and gravity

$$C.I = \frac{48640}{T_B} + 473.7S - 456.8$$

TB is the average modal boiling point ( K)

S: is the specific gravity at 60 °F

C.I for Parafine =0

C.I for Benzene =100

C.I =0-15 Parafine

C.I =15-50 either Naphtenes or mix (Parafine + Naphtenes)

C.I = above 50 Aromatic

## 6) Viscosity Index : (V.I)

A series of numbers ranging from 0-100 which indicate the rate of change of viscosity with temperature.

Paraffinic base C.O V.I =100

Naphthenic base C.O V.I = 40

Some Naphthenic base C.O V.I =0

## The presence of impurities in the crude oil

### 1. Sulfur

Difficulties with oils that contain sulfur compounds arise in only three main ways: corrosion, odor and poor explosion characteristics of gasoline fuels.

a) Corrosion: corrosion by finished products presents little difficulty because most products are used at low temperatures. The main bulk of the corrosive sulfur compounds can be removed by treatment with alkalis or the sweetening treatments. In presence of air and moisture the sulfur gases produced during the burning of oil may cause corrosion, as in steel stacks, ducts, and engine exhaust pipes and mufflers.

Real difficulties arise when high sulfur oils are heated to temperature 300 °F or higher for copper, or 400 °F for steels.

b) Odor : Odor is most obnoxious with low boiling or gaseous sulfur compounds, as H<sub>2</sub>S or SO<sub>2</sub> in flue gases, mercaptans up to even six carbons atoms (B.P. of about 400 °F), sulfides up to 8 carbons atoms (about 350 °F), and among disulfides only methyl disulfide (B.P. 243 °F) . This odor is not obnoxious in sweetened products except in certain extremely high- sulfur gasoline.

Percentage of S in crude oil ranges from nearly 0.1 for high API- gravity crude oils as high 5 percentage in a few very heavy crude oils.

Generally crude with greater than 0.5% S require more extensive processing than those with lower sulfur content.

## **2. Salt**

Salt carried into the plant in brine associated with crude oils is a major cause of the plugging of exchangers and coking of pipe still tubes.

If salt content expressed as NaCl, is greater than 10 lb/1000 bbl, it is generally necessary to desalt the crude before processing.

## **3. Carbon Residue**

The less the value of carbon residue the more valuable the crude.

## **4. Nitrogen Compounds:**

The nitrogen compounds in petroleum are not of major importance, but they do tend to cause a reduction in the activity of the catalysts used in catalytic cracking and they may assist in the formation of so-called "gum" in distilled or diesel fuel oil.

Crude containing in amount above 0.25 % by weight require special processing to remove the nitrogen.

## **5. Hydrocarbons Gaseous**

The amount of gaseous hydrocarbons dissolved in crude oil is almost totally a function of the degree of weathering that the oil has undergone or the pressure at which it is collected. The percentage of involved when the dissolved gases are lost cannot be stated with accuracy but it is about

**Reid V. P -1**

**Liquid vol. % loss =-----**



If the gas have M.W= 40, the gas amount to about 16.1 ft<sup>3</sup> per 1% loss of liquid.

## **6. Metallic Content (Ni, V, Cu)**

The metal content in crude oil can vary from a few ppm to more than 1000 ppm, disadvantages affect activities of catalyst, corrosion, deterioration of refractory furnace lining and stacks. Can be reduced by solvent extraction with C<sub>3</sub>.

## Analysis of Crude Petroleum

**1) Distillation Curves** : When a refining company evaluate its own crude oils to determine the most desirable processing sequence to obtain the required products, its own laboratories will provide data concerning the distillation and processing of the oil and its fractions. The first step in refinery is distillation in which the crude oil separated into fractions according to its boiling point.

There are at least four types of distillation curves or ways of relating vapor temperature and percentage vaporized.

**a) True-boiling-point (T.B.P):** (Fractional, run only on crude oil, batch) .

Distillation characteristics of a crude are assessed performing a preliminary distillation called "True Boiling Point" analysis (TBP). This test enlightens the refiners with all possible information regarding the percentage quantum of fractions, base of crude oil and the possible difficulties beset during treatment operation etc.

True boiling point (TBP) and gravity-mid percent curves can be developed from U.S Bureau of mines crude petroleum analysis data sheet Fig. (1) which is reported in two portions: The first is the portion of the distillation at atmospheric pressure and up to **527 °F (275 °C)** end point, the second at 40 mm Hg total pressure to **572 °F (300 °C)** end point.

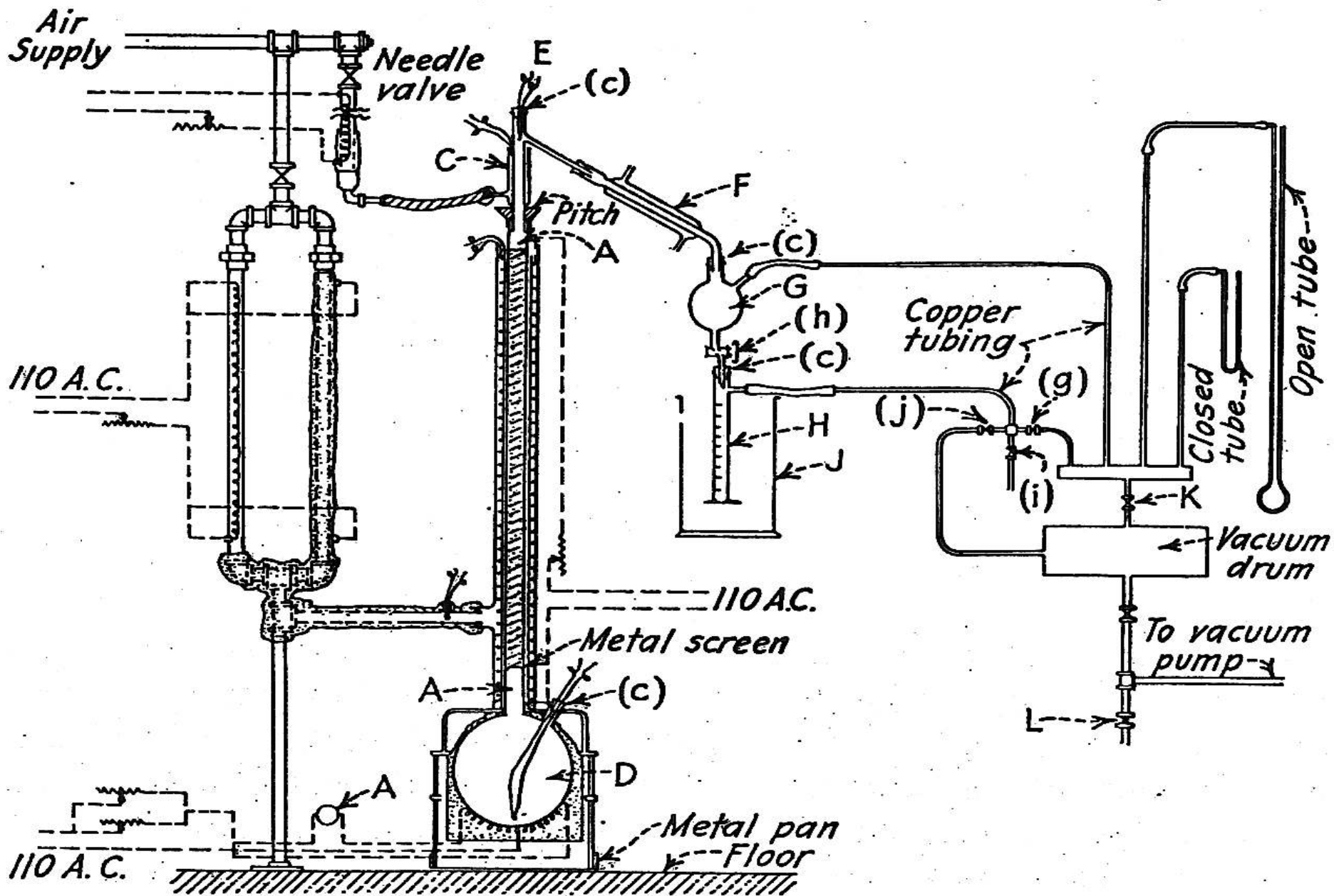


FIG. 4-7. Diagram of a true-boiling-point apparatus.

The portion of distillation at reduced pressure is necessary to prevent excessive pot temperature which cracking of the crude oil. The distillation temperatures reported in the analysis be corrected to 760 mm Hg pressure. Generally, those reported in the atmospheric distillation section need to be corrected. The distillation temperature at 40 mm Hg can be converted to 760 mm Hg by use of chart Fig. (2) shows the relationships between boiling temperatures at 40 mm Hg and 760 mm Hg pressure. The gravity mid-percent curve is plotted on the same chart with TBP. The gravity should be plotted on the average volume percent of the fraction, as the gravity is the average of the gravities from the first to the last drops in the fractions. For narrow cuts, a straight line relationship can be assumed and the gravity used as that of the mid-percent of the fraction. Smooth curves are drawn for both TBP and gravity mid-percent curves. Fig. (3) illustrated these curves for the crude oil.

**b) Equilibrium or Flash Vaporization (EFV).** The feed material is heated as it flows continuously through a heating coil. As vapor is formed it kept cohesively with liquid at some temperature and a sudden release of pressure quickly flashes or separates the vapor from the mixture without any rectification. By successive flash evaporation like this the stock can be progressively distilled at different increasing temperatures. a curve of percentage vaporized vs. temperature may be plotted.

travels along in the tube with remaining liquid until separation is permitted in a vapor separator or vaporizer. By conducting the operation at a series of outlet temperature, a curve of percentage vaporized vs. temperature may be plotted.

**c) ASTM or no fractionating distillation: (no fractional , run on fractions) .**

It is supposed to be like EFV, a non fractionating distillation system, distinguishing itself as differential distillation. It is a simple distillation carried out with standard ASTM flasks 100,200,500 ml flasks. The data obtained is similar to TBP data



Fractionation column like (IP24 or D86).

**d) Hempel: (Semi fractional).**

It is considered as a semi-fractionating type of distillation like Saybolt 's, Where TBP data is insufficient , this can be used.

# CRUDE PETROLEUM ANALYSIS

Bureau of Mines Bartlesville Laboratory  
Sample 53016

## IDENTIFICATION

Hastings Field

Texas  
Brazoria County

## GENERAL CHARACTERISTICS

Gravity, specific, 0.867 Gravity, ° API, 31.7 Pour point, ° F., below 5  
Sulfur, percent, 0.15 Color, brownish green  
Viscosity, Saybolt Universal at 100° Nitrogen, percent, \_\_\_\_\_

## DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 751 mm. Hg  
First drop, 84 ° F.

Fraction No.	Out temp. ° F.	Percent	Sum. percent	Sp. gr. 60/60° F.	° API. 60° F.	C. I.	Refractive index, n <sub>D</sub> at 20° C.	Specific dispersion	S. U. Visc. 100° F.	Cloud test. ° F.
1	122	0.8	0.8	0.673	78.8					
2	167	1.0	1.8	.685	75.1	15				
3	212	3.0	4.8	.725	63.7	24	1.39574	127.7		
4	267	3.4	8.2	.755	55.9	29	1.41756	128.6		
5	302	3.1	11.3	.777	50.6	32	1.42985	135.4		
6	347	3.9	15.2	.798	45.8	35	1.44192	137.8		
7	392	4.9	20.1	.817	41.7	38	1.45217	139.9		
8	437	6.8	26.9	.833	38.4	40	1.46057	140.3		
9	482	8.0	34.9	.848	35.4	41	1.46875	148.0		
10	527	10.9	45.8	.864	32.3	44	1.47679	149.8		

Stage 2—Distillation continued at 40 mm. Hg

11	302	7.3	53.1	0.873	30.6	45	1.48274	155.2	42	Below 5
12	437	7.8	60.9	.879	29.5	44	1.48474	156.2	50	do
13	482	6.2	67.1	.889	27.7	45	1.49058	152.7	71	do
14	527	5.7	72.8	.901	25.6	48			125	10
15	572	6.9	79.7	.916	23.0	52			280	20
Residuum		20.3	100.0	.945	18.2					

Carbon residue, Conradson: Residuum, 4.7 percent; crude, 1.0 percent.

## APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	4.8	0.708	68.4	
Total gasoline and naphtha	20.1	0.771	52.0	
Kerosene distillate	--	--	--	
Gas oil	36.9	0.858	33.4	
Nonviscous lubricating distillate	10.2	.879-.895	29.5-26.6	50-100
Medium lubricating distillate	5.8	.895-.908	26.6-24.3	100-200
Viscous lubricating distillate	6.7	.908-.924	24.3-21.6	Above 200
Residuum	20.3	0.945	18.2	
Distillation loss	0			

Figure (1) U.S Bureau of Mines crude petroleum analysis (From Gary and Handwerk, 2001)

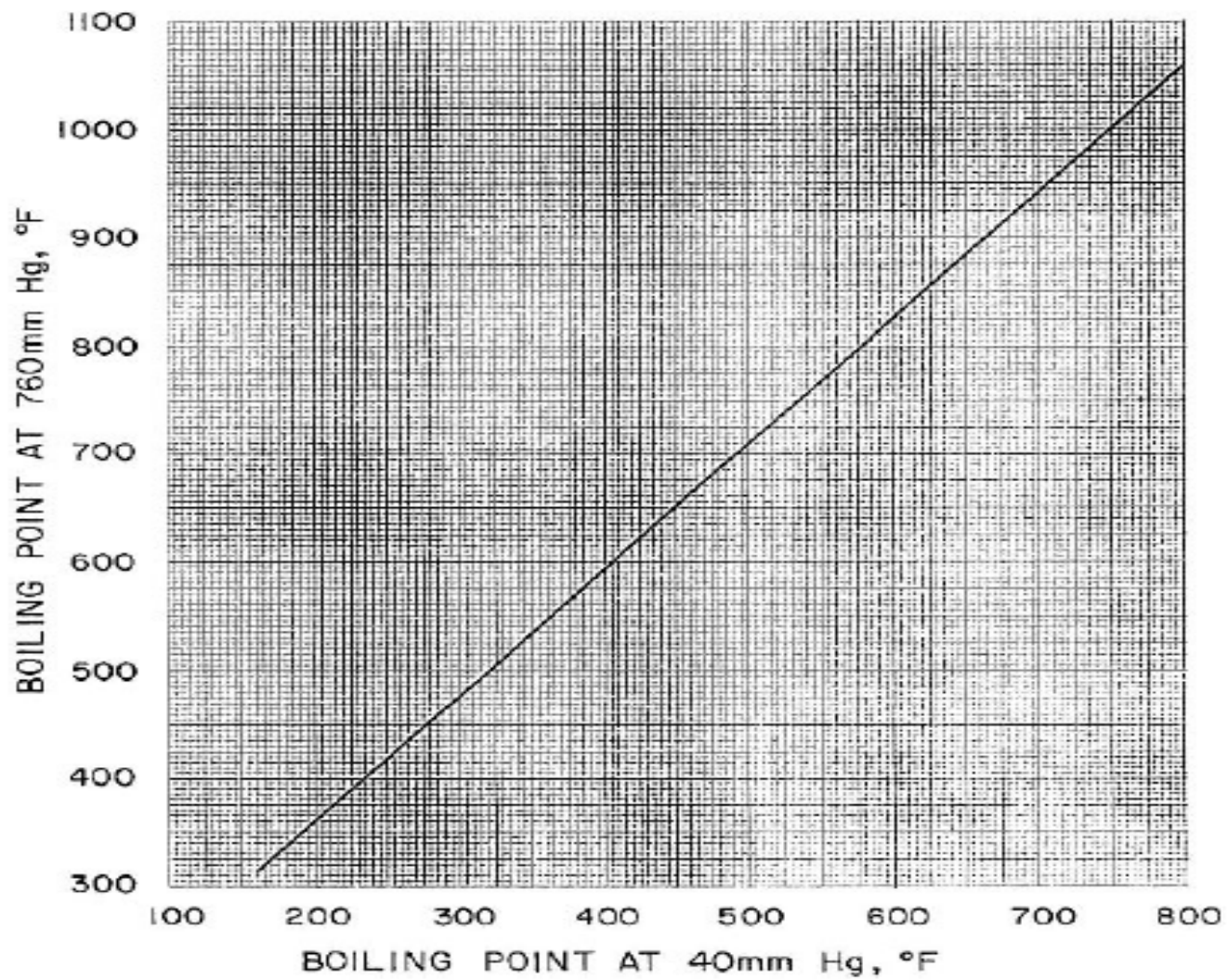


Figure (2) Boiling point at 760 mmHg versus boiling point at 40mmHg (From Gary and Handwerk, 2001)

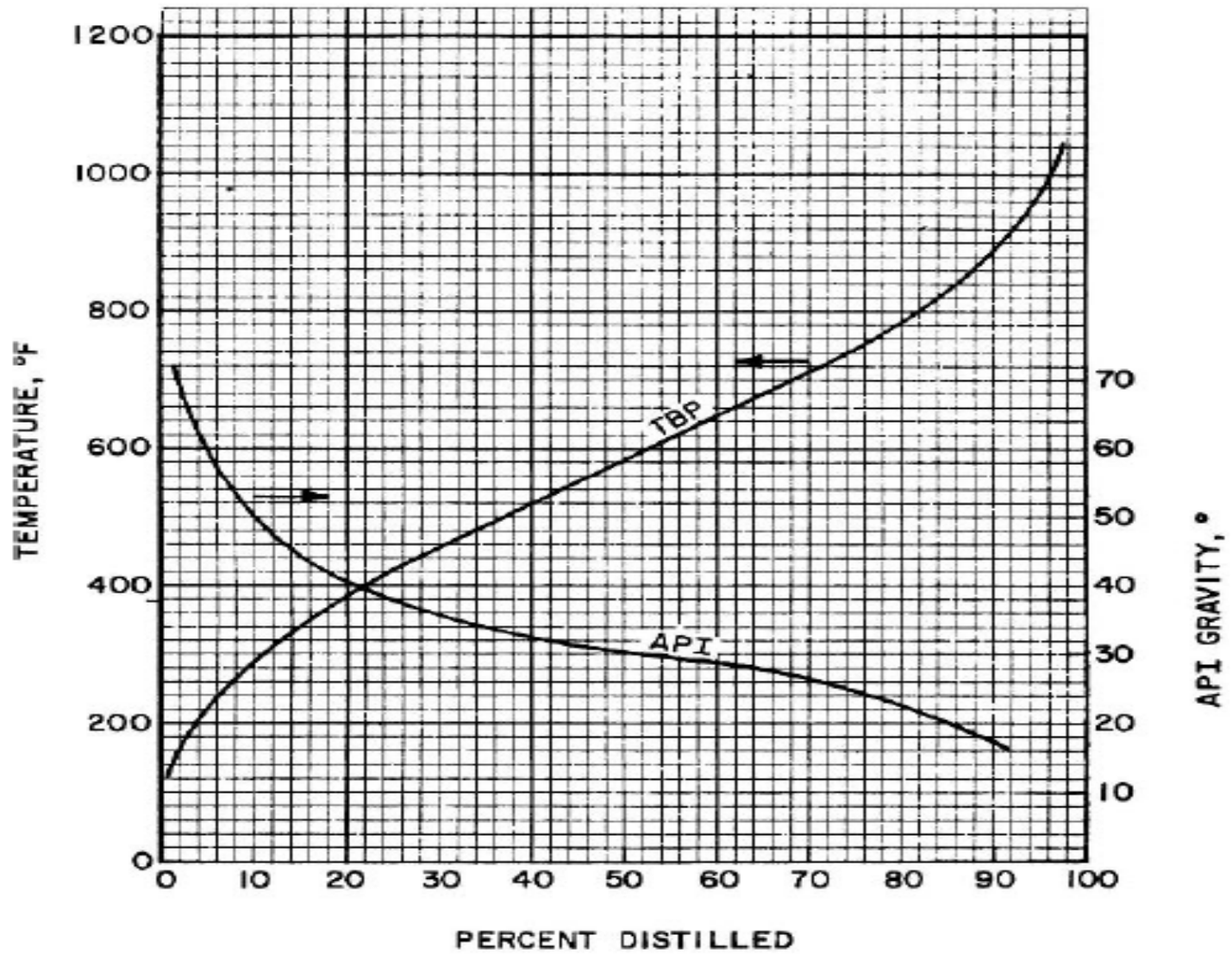


Figure (3): TBP and gravity- mid percent curves. Hasting Field, Texas crude: gravity 31.7 °API; sulfur, 0.15 wt%. (From Gary and Handwerk, 2001)



## 2) Mid Percent Curves:

The physical properties of an oil found to vary gradually throughout the range of compounds that constitute the oil. Distillation is a means of arranging of compounds these chemical compounds in order of their boiling points. The properties such as color, specific gravity, and viscosity are found to be different for each drop or fraction of the material distilled. The rate at which these properties change from drop to drop may plot as mid per cent curves.

In reality, the specific gravity or viscosity of a fraction is an average of the properties of the many drops that constitute the fraction. If each drop is equally different from the last drop and from the succeeding one, then the drop that distills at exactly half of the fraction has the same property as the average of all the drops. This would be the condition for a mid per cent that is a straight line, but they are substantially straight through any short range of percentage. For a short range of percentage the average property is equal to the property at the mid-point of the fraction. The arithmetical average of the properties of these small fractions is the property of the total or large fraction, or even the entire sample.

Integral- averaging by adding together the properties of a series of short fractions and dividing by number of fractions can not be used on properties that are not additive. Specific gravity (not API gravity) is an example of an additive property, e. g. 10 volumes of an oil of specific gravity 0.8 when mixed with an equal volume of 0.9 specific gravity oil yields a mixture that has a specific gravity 0.85.

Additive Properties	Non additive Properties
Boiling Point (T.B.P)	API Gravity
Vapor Pressure	Viscosity
Specific Gravity	Color
Aniline Point	Flash Point
Sulfur Content	
Hydrogen/Carbon ratio	

### **3) Yield Curves:**

If a property is not additive, the property of various ranges of fractions can be determined experimentally by blending and plotting the property value as obtained as a function of yield or amount of blended material.

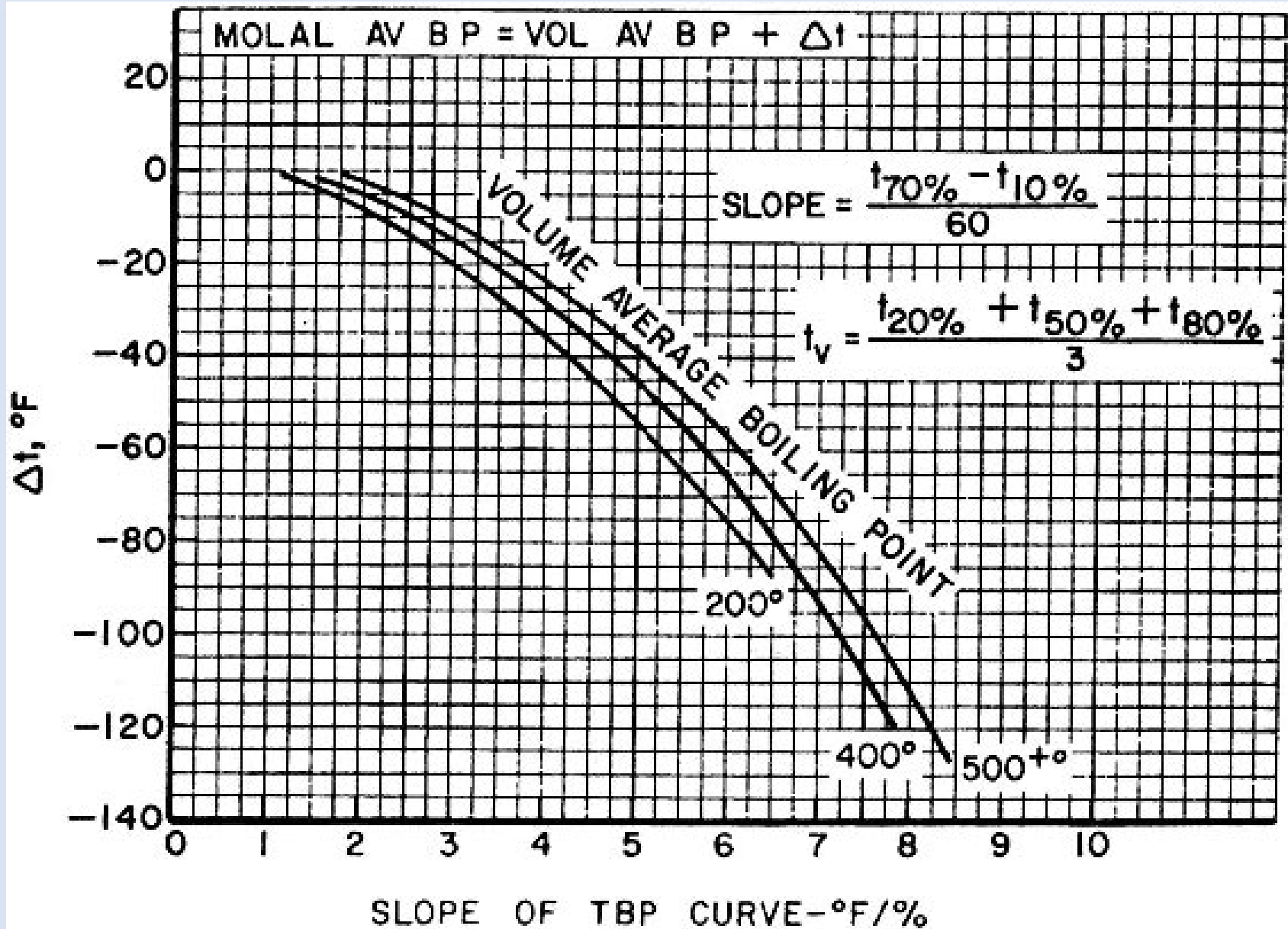
## Crude Suitable for Asphalt Manufacture

If a crude oil residue (750 °F mean average boiling point) having a Watson characterization factor < 11.8 and gravity < 35 °API , it is usually suitable for asphalt manufacture.

If however, the difference between the K values for the 750 °F and 550 °F fraction is greater than 0.15, the residue may contain too much wax to meet most asphalt specification.

## Calculation of (K) (Characterization Factor) for The Whole Crude

1. Calculate the TVABP using 20, 50, and 80 volume % TBP temperature.
2. Calculate the 10 to 70% slope of the whole curve.
3. Using a proper correction factor, convert TVABP to TMABP. (or some time given ):  
(TMABP=TVABP- $\Delta T$ )
4. Construct a spg mid percent curve and evaluate the spg for the whole crude.
5. K is found as a function of TMABP and spg.



Fig(4) Molal average boiling point of petroleum fractions. (From Gary and Handwerk, 2001)

## Estimation of EFV Distillation Curve

### A- Estimation of the straight line EFV curve:

1. Estimate of  $t_{50\%}$  of ASTM/ TBP using Fig. (8)
2. Estimate the 10 to 70% slope of ASTM/TBP using

$$\text{Slope}(ASTM / TBP) = \frac{t_{70} - t_{10}}{60}$$

3. Use Fig. (5) to convert slope (ASTM/TBP) to slope of EFV

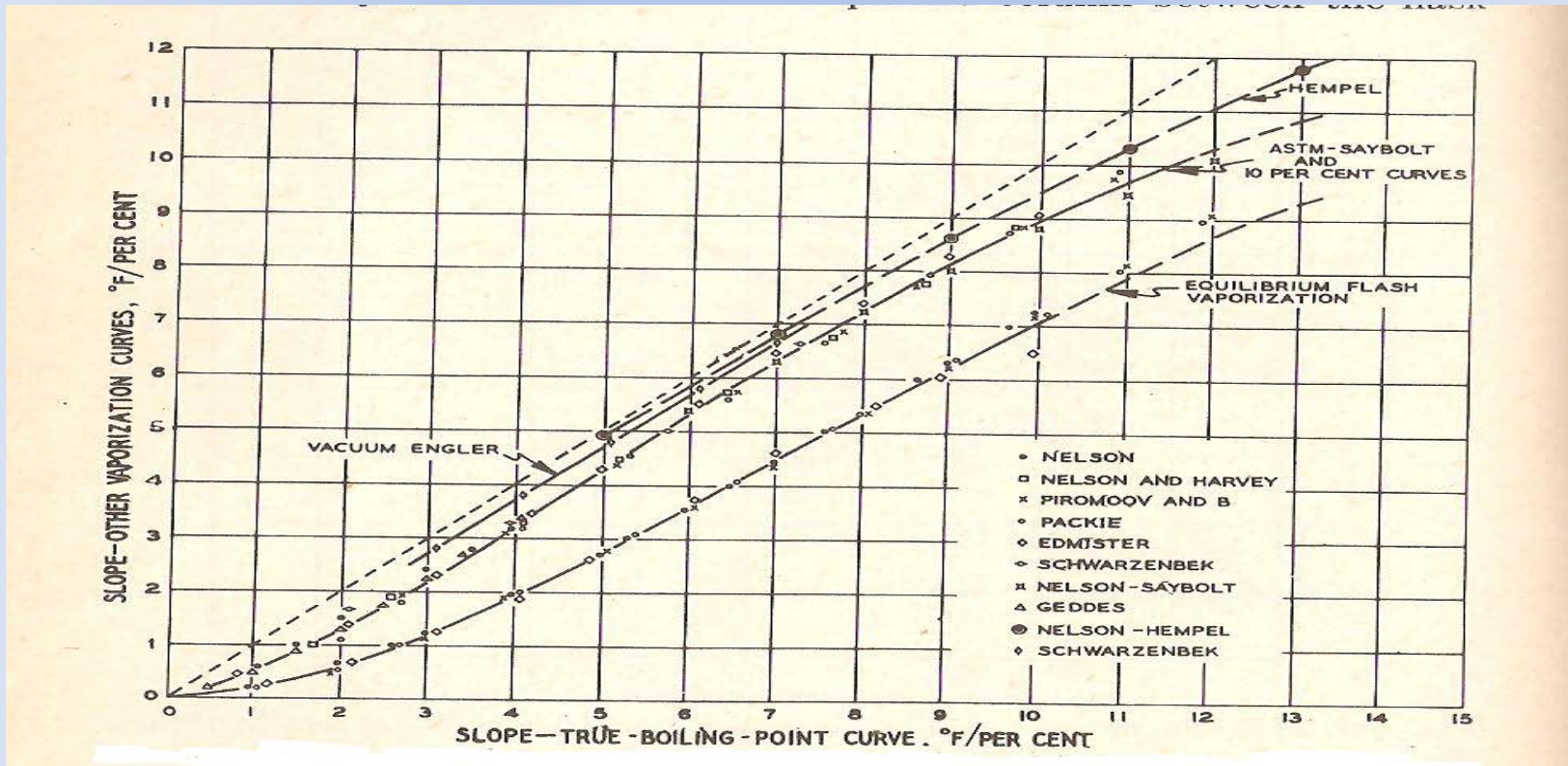


Fig (5): Relationships between the slopes (degrees/ per cent) of various distillation or vaporization curves. (From, Nelson, W. L, 1985)

4. Estimate  $t_{50\%}$  of EFV from Fig. ( 6 )

$$t_{50\% \text{ EFV}} = t_{50\% \text{ ASTM/TBP}} - \Delta T$$

5. Draw a straight line through  $t_{50\%}$  EFV with slop of EFV.

6.  $t_{0\%}$  ( bubble point ) =  $t_{50\% \text{ EFV}} - \text{slope} * (50)$

7.  $t_{100\%}$  (dew point) =  $t_{50\% \text{ EFV}} + \text{slope} * (50)$

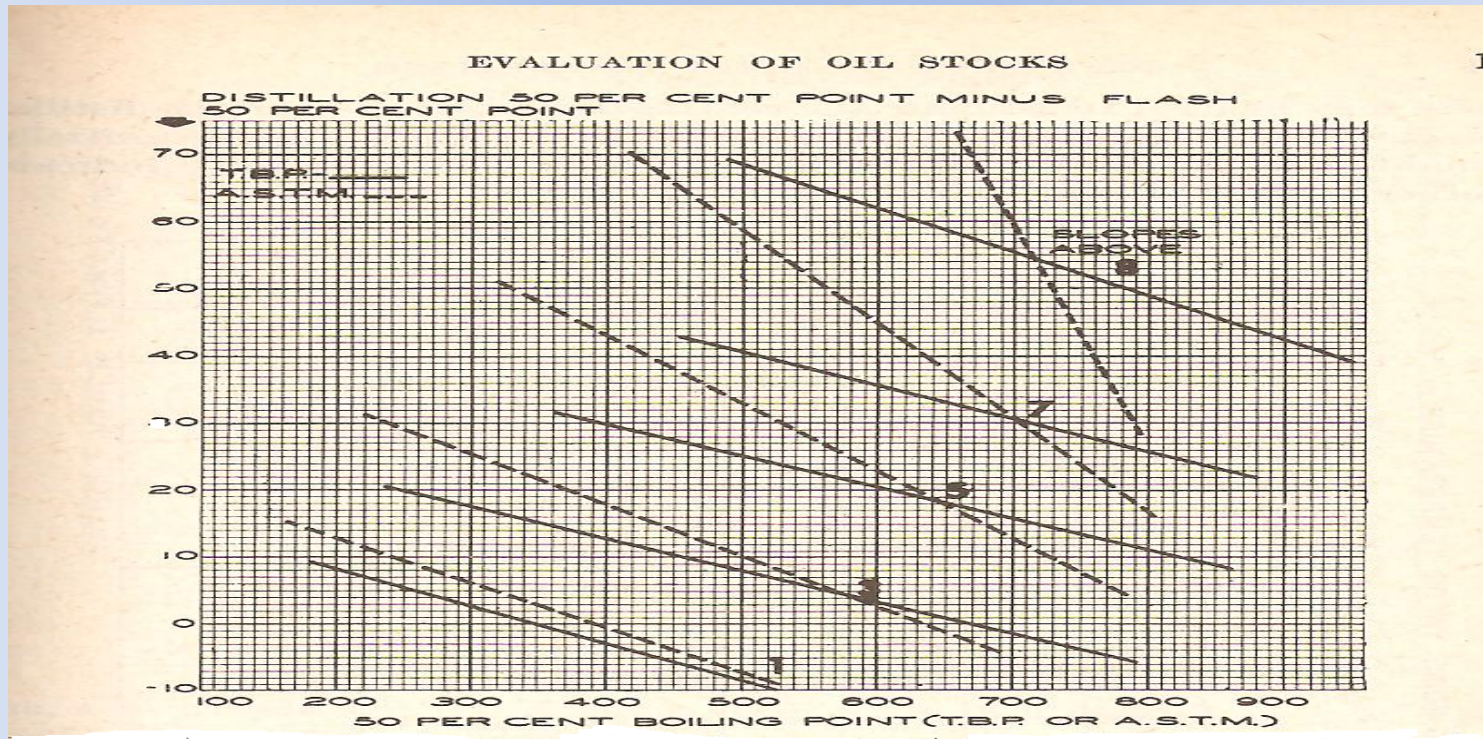


Fig (6): Relationship between distillation temperatures at 50 per cent vaporized and the flash (E. F.V.) temperatures at 50 per cent. (From, Nelson, W. L, 1985)

## B. Estimation of EFV Curvature

1. Estimate  $t_{50\%}$  (ASTM/TBP)

The proper 50% temperature is intermediate between the temperature on the distillation curve and the temperature on a straight line connecting the 10 and 70 percent points, and usually about halfway between.

2. Convert to  $t_{50\%}$  EFV using Fig (6)

3. Estimate the (ASTM/TBP) 10-70 % slope

4. Estimate the EFV slope from Fig (5)

5. Estimate  $t_{100\%}$  on flash curve =  $t_{50\%} + \text{slope} * (50)$

$t_{0\%}$  on flash curve =  $t_{50\%} - \text{slope} * (50)$

6. Ratio of 10-70 slopes = R

7. Starting at the 10 % and compute the 5 %

$t_{10\%} = t_{50\%} - 40 * (\text{slope})$

EFV

8. Slope of (ASTM/TBP) through 5-10 % = r

9. Slope of EFV through 5-10 % = r / R

10. Temperature at 5 % on EFV =  $t_{10\%} - \text{slope} * (5)$

$$R = \frac{\text{Slope of dist. Curve (10 -70)}}{\text{Slope of flash. Curve (10 -70)}} = \frac{\text{Slope of dist. Curve through short range (r)}}{\text{Slope of EFV through short range}}$$

## Average Boiling point

### 1) Volume Average Boiling Point (TVABP)

$$TVABP = \frac{t_{10\%} + t_{20\%} + \text{-----} + t_{90\%}}{9}$$

If such data is not available then it may be defined as

$$TVABP = \frac{t_{30\%} + t_{50\%} + t_{80\%}}{3}$$

Where all % are in volumes

### 2) Weight Average Boiling Point (TWABP)

$$TWABP = \frac{t_{10\%} + t_{20\%} + \text{-----} + t_{90\%}}{9}$$

Where % are based on weight



### 3) Molar Average Boiling Point (TMABP)

$$TWABP = \frac{t_{x_1} + t_{x_2} + t_{x_3}}{x_1 + x_2 + x_3}$$

where  $x_1, x_2, x_3$  are mole fractions

$t_{x_1}, t_{x_2}, t_{x_3}$  are corresponding boiling points.

All these boiling point are interconvertable.

Interconvertability of boiling points can be worked out by knowing the slope of distillation curve of a fraction. The method of finding out the slope for ASTM/TBP/EFV is the same

TBP slope is given as  $\frac{t_{70} - t_{10}}{60}$  i.e. °t/ percent; where 70% and 10% are volumetric boiling points on vaporization curve.

The conversion of TBP slope to ASTM or EFV slope can be done with Fig (5)

### Example (1) :( Use of Gravity Mid percent Curve) (Nelson p/106)

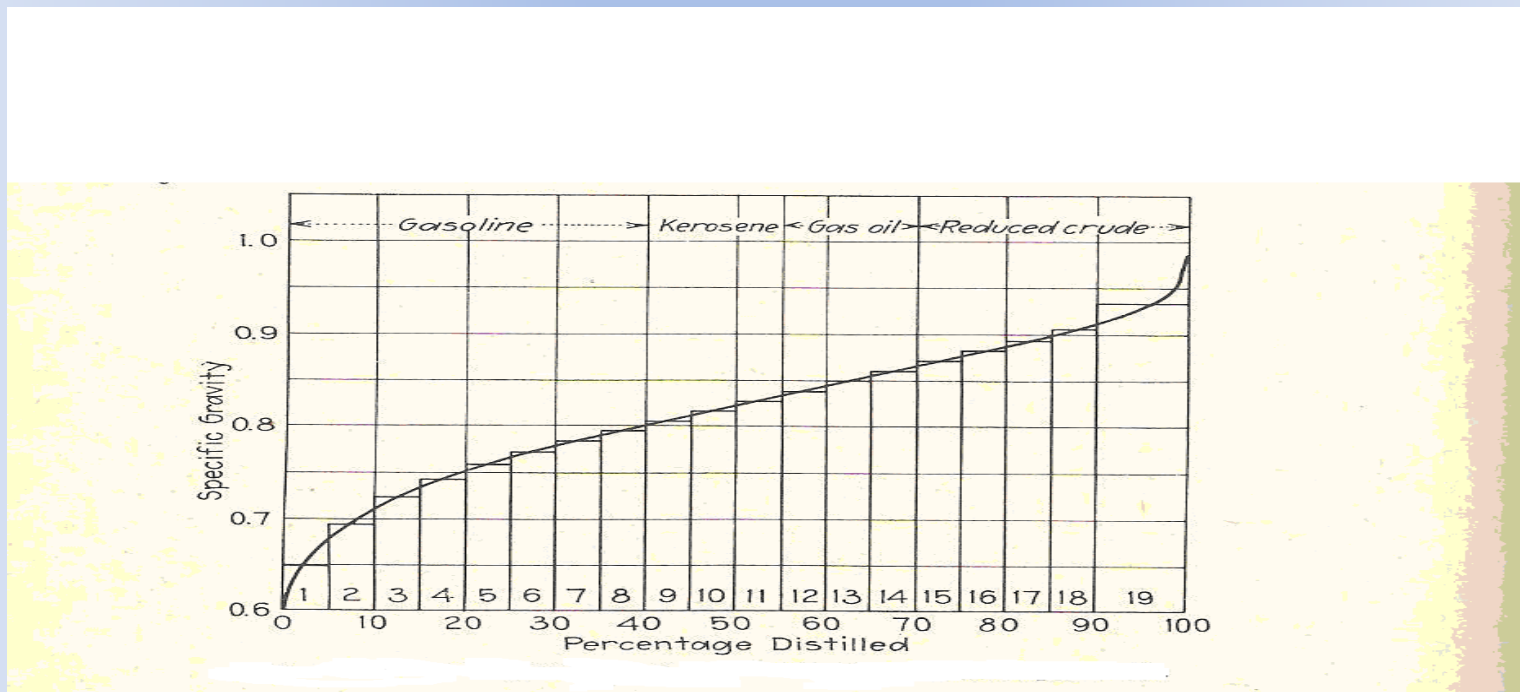
Compute the spg of a 41.4 API (0.8183 spg) mixed base crude oil from the spg mid percent

Fraction No.	Range of %	spg	Fraction No.	Range of %	spg
1	0-5	.7006	11	50-55	.8280
2	5-10	.6939	12	55-60	.8388
3	10-15	.7227	13	60-65	.8498
4	15-20	.7420	14	65-70	.8602
5	20-25	.7583	15	70-75	.8713
6	25-30	.7720	16	75-80	.8827
7	30-35	.7844	17	80-85	.8939
8	35-40	.7958	18	85-90	.9065
9	40-45	.8067	19	90-95	.9340
10	45-50	.8170			

$$5(0.65+0.69+0.72+0.74+0.76+0.77+0.78+0.79+0.81+0.815+0.82+0.83+0.85+0.86+0.87+0.88+0.89+0.91)+10(0.93)$$

$$\text{Spg of c.o} = \frac{\text{-----}}{100}$$

Computed Sp.gr = 0, 8171, Actual Sp.gr = 0.8183 reasonable check (good for most engineer design work), See fig (7).



**Fig (7): Gravity mid per cent curve. (From, Nelson, W. L, 1985)**

## Example (2): (Estimate of Flash Vaporization Curve) p/113 Nelson

1) The TBP curve of Fig (8) has a slope (degree/percent) between 10 and 70 percent point of;

$$\frac{t_{70} - t_{10}}{60} = \frac{775 - 210}{60} = 9.4 \quad \text{Deg/percent}$$

3) From Fig (8), 50 % percent temperature of TBP curve =576 °F

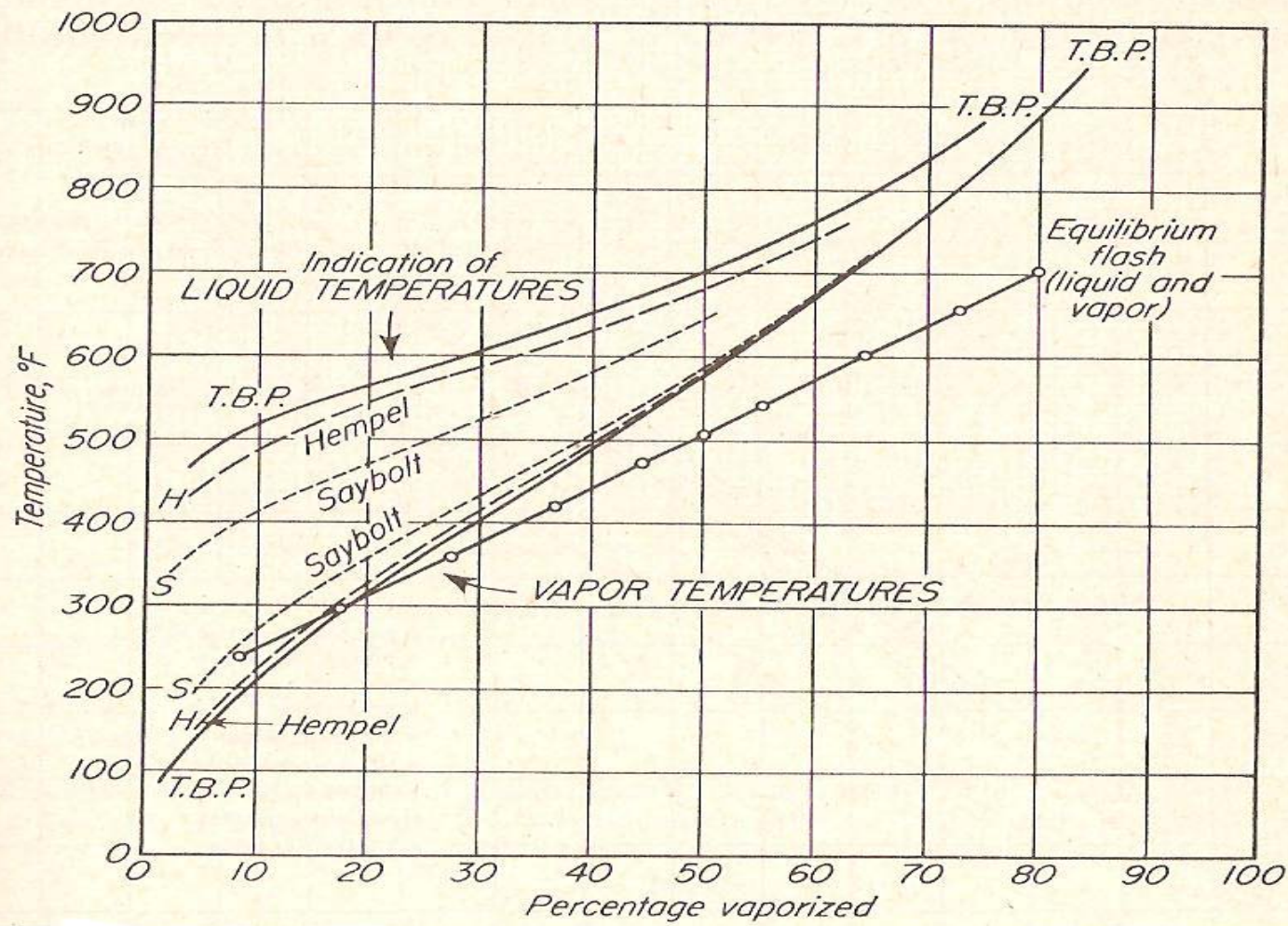
4) From Fig (6), the 50 % percent temperature of flash curve will be about 64 °F below of 50 percent temperature of the TBP curve

$$576 - 64 = 512 \text{ } ^\circ\text{F}$$

6) A straight line flash curve can be drawn through 512 °F with slope of 6.5

Thus at zero percent the temperature =  $512 - 50 * 6.5 = 187 \text{ } ^\circ\text{F}$

At 100 percent the temperature =  $512 + 50 * 6.5 = 837 \text{ } ^\circ\text{F}$



**Fig (8) typical liquid and vapor temperature distillation of a 35 API crude oil**

(From, Nelson, W. L, 1985)

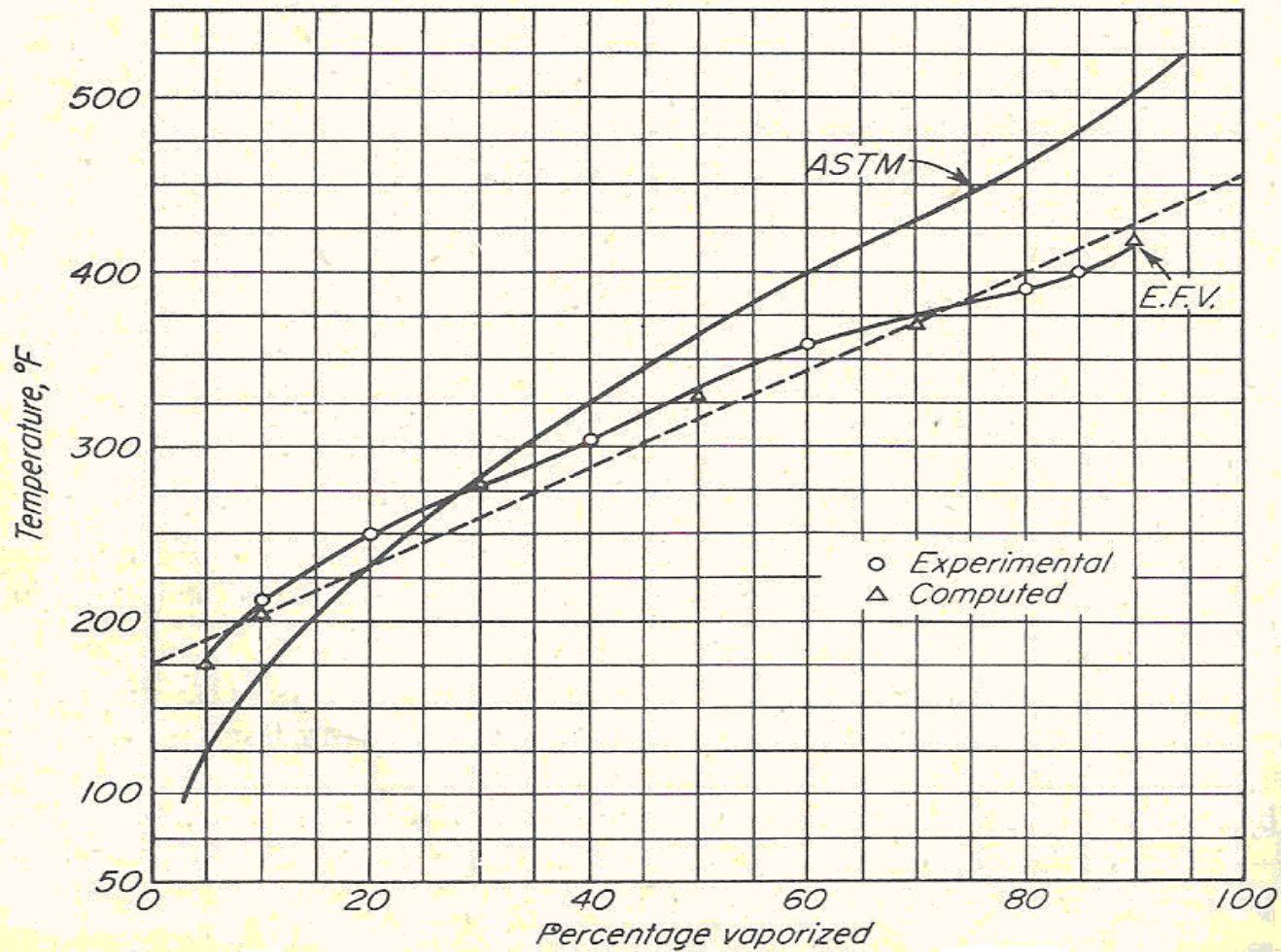
$$\frac{170 - 125}{5} = 9.0$$

8) Slope of flash curve between 5 and 10 %

$$R = \frac{\text{Slope of dist. Curve}(10 - 70)}{\text{Slope of flash. Curve}(10 - 70)} = \frac{\text{Slope of dist. Curve through short range (r)}}{\text{Slope of EFV through short range}}$$

$$= \frac{4.34}{2.8} = \frac{9}{\text{Slope of flash through short range}}$$

Temperature at 5 % on flash curve =  $205 - 5.8 * 5 = 176 \text{ } ^\circ\text{F}$



**Fig (9): Curvature in the distillation curves of a pressure still distillate.**

**(From, Nelson, W. L, 1985)**

## Conversion between ASTM and TBP Distillation

The following equation suggested by Riazi and Daubert

$$\text{TBP} = a(\text{ASTM D86})^b$$

where  $a$  and  $b$  are constants varying with percent of liquid sample distilled as given in Table 3

TBP is true boiling point temperatures at 0, 10, 30, 50, 70, 90, and 95 volume percent distilled, in degrees Rankin.

ASTM D86 is the observed ASTM D86 temperatures at corresponding volume percent distilled, in degrees Rankin.

Table 3

Volume % distilled	$a$	$b$
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



## Example

A petroleum cut has the following ASTM D86 Distillation data:

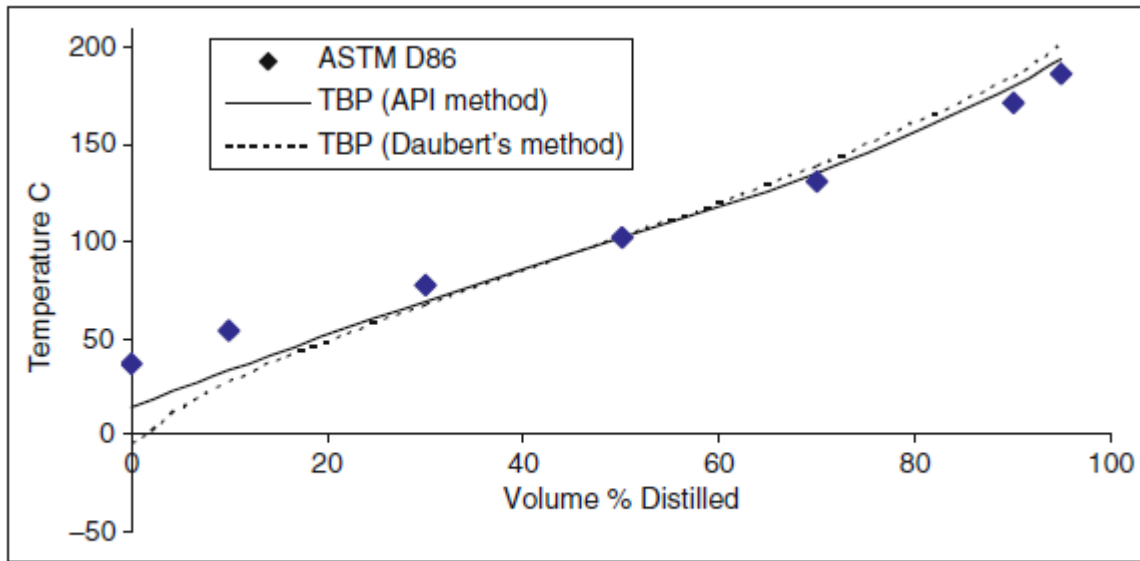
Volume % distilled	0	10	30	50	70	90	95
Temperature (°C)	36.5	54	77	101.5	131	171	186.5

Convert these data to TBP data using the API method of Riazi and Daubert and Daubert's method. Plot the results and compare.

## Solution

Application of the API method is straightforward using equation (3) and the constants in Table 3

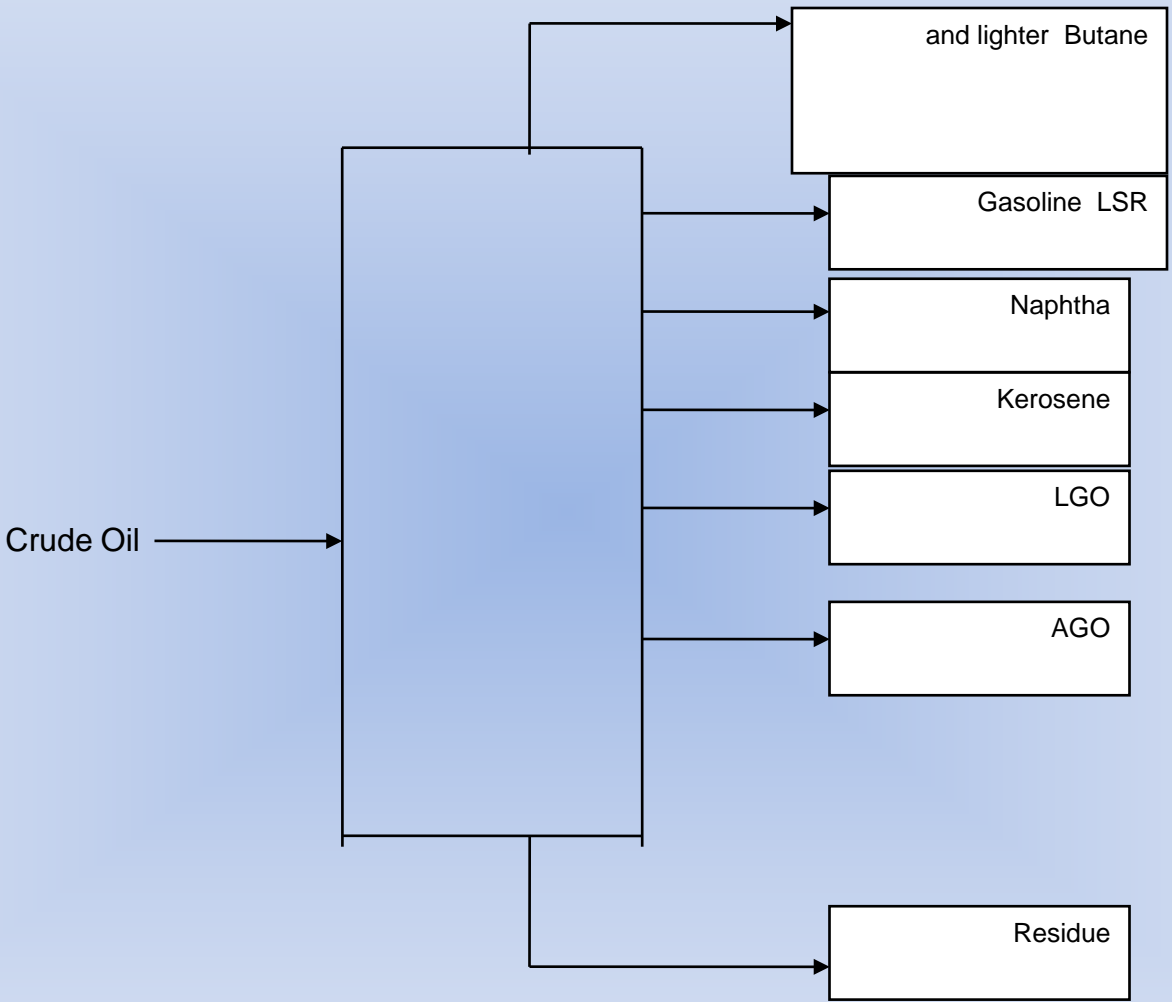
Volume % distilled	D86 T (°C)	TBP (°C) API method equation (3.3)
0	36.5	14.1
10	54	33.4
30	77	69.0
50	101.5	101.6
70	131	135.2
90	171	180.5
95	186.5	194.1



**Figure E3.1** Conversion of ASTM D86 into TBP

As can be seen from Figure E3.1, the TBP distillation curve is below the ASTM curve at volume distilled below 50% and above it for volume distilled above 50%.

**Distillation Fractions:** All the components that boil between the two specified temperature which called the cut point



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Fractions	Cut points	Cut points
C4 and ltr	< 32 °C	< 90 °F
Light Straight Run (LSR) Gasoline	32-105 °C	90-220 °F
Naphtha HSR	105-150 °C	220-300 °F
Kerosene	150-282 °C	300-540 °F
Gas oil	282-425 °C	540-800 °F
Residue	425+ °C	800 + °F

### **Cut Point**

Each fraction has an **IBP** and **EP** on **ASTM** curve because of an efficient fractionation the **IBP** of heavier fraction is interrelated with the **EP** of lighter fraction.

**H.W (4.1):** The ASTM data for a pressure distillation are as given. Estimate the EFV curve.

% volume dist.	ASTM (temp. )	% volume dist	ASTM (temp. )
5	125	50	365
10	175	55	380
15	200	60	400
20	230	65	420
25	255	70	425
30	280	75	450
35	300	80	460
40	325	85	480
45	350	90	500

**H.W (4.2):** Evaluate the crude oil whose  $^{\circ}\text{API}= 35$ ,  $\text{MABP}=600$ ,  $\text{sulfur}\%= 0.52\%$ .

**H.W (4.3):** 4000 BPD of (35 ° API) crude oil having the given TBP data is available.

TBP °F	% vol. Distilled	°API	% Sulfur
80	1	110	-
180	13	63	-
380	30	49	0.1
510	50	38	0.3
620	63	23	0.5
750	73	20	0.8
1000	84	17	1.5
1000+	100	11	2.3

- Draw an assay curve.
- Evaluate the given crude ;  $TMABP = TVABP - 120$  ( ° F )
- Select TBP cut temperature for the products to be obtained from distilling this crude and estimate their yields.

**H.W (4.4)** : For the given crude oil ;

a) Evaluate the given oil.

b) Select TBP cut points for the products to be obtained from processing this crude in an atmospheric distillation unit and estimate the %yield for each cut.

% vol. Distilled	TBP (°F )	API	% S
0	40	---	---
20	200	40	0.1
40	280	35	0.18
60	330	30	0.25
80	410	26	0.42
90	500	25	0.68
95	520	20	0.8

**H.W (4.5)** : For the given crude oil (31.7 °API ),sulfur percent 0.15 ;

a) Evaluate the given oil.

b) Select TBP cut points for the products to be obtained from processing this crude in an atmospheric distillation unit and estimate the %yield for each cut.

Stage 1- Distillation at atmospheric pressure 751 mm Hg

Fraction No.	Cut Temp. °F	Percent Distilled	Sum. Percent	Sp. gr. 60/60 °F	°API 60 °F
1	122	0.8	0.8	0.673	78.8
2	167	1.0	1.8	0.685	75.1
3	212	3	4.8	0.725	63.7
4	257	3.4	8.2	0.755	55.9
5	302	3.1	11.3	0.777	50.6
6	347	3.9	15.2	0.798	45.8
7	392	4.9	20.1	0.817	41.7
8	437	6.8	26.9	0.833	38.4
9	482	8.0	34.9	0.848	35.4
10	527	10.9	45.8	0.864	32.3



## Stage 2- Distillation at atmospheric pressure 40 mm Hg

Fraction No.	Cut Temp. °F	Percent Distilled	Sum. Percent	Sp. gr. 60/60 °F	° API 60 °F
11	392	7.3	53.1	0.873	30.6
12	437	7.8	60.9	0.879	29.5
13	482	6.2	67.1	0.889	27.7
14	527	5.7	72.8	0.901	25.6
15	572	6.9	79.7	0.916	22.94
16	-----	20.3	100.0	0.945	18.2