Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering Department

Properties of Petroleum & Natural Gas

Third Class

Lecture 13

By

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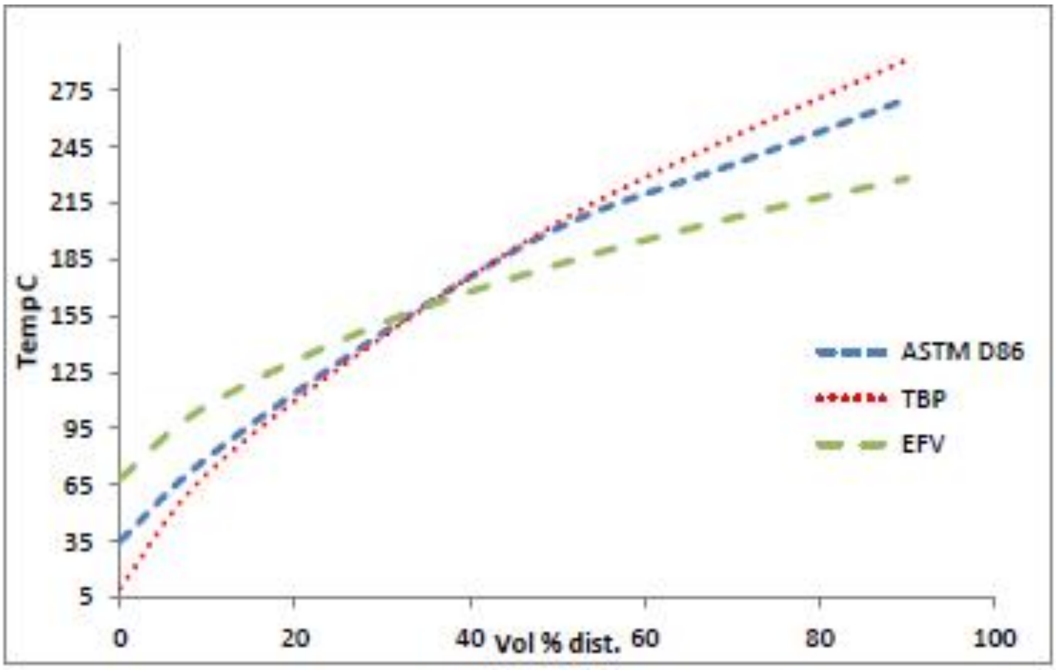


Figures

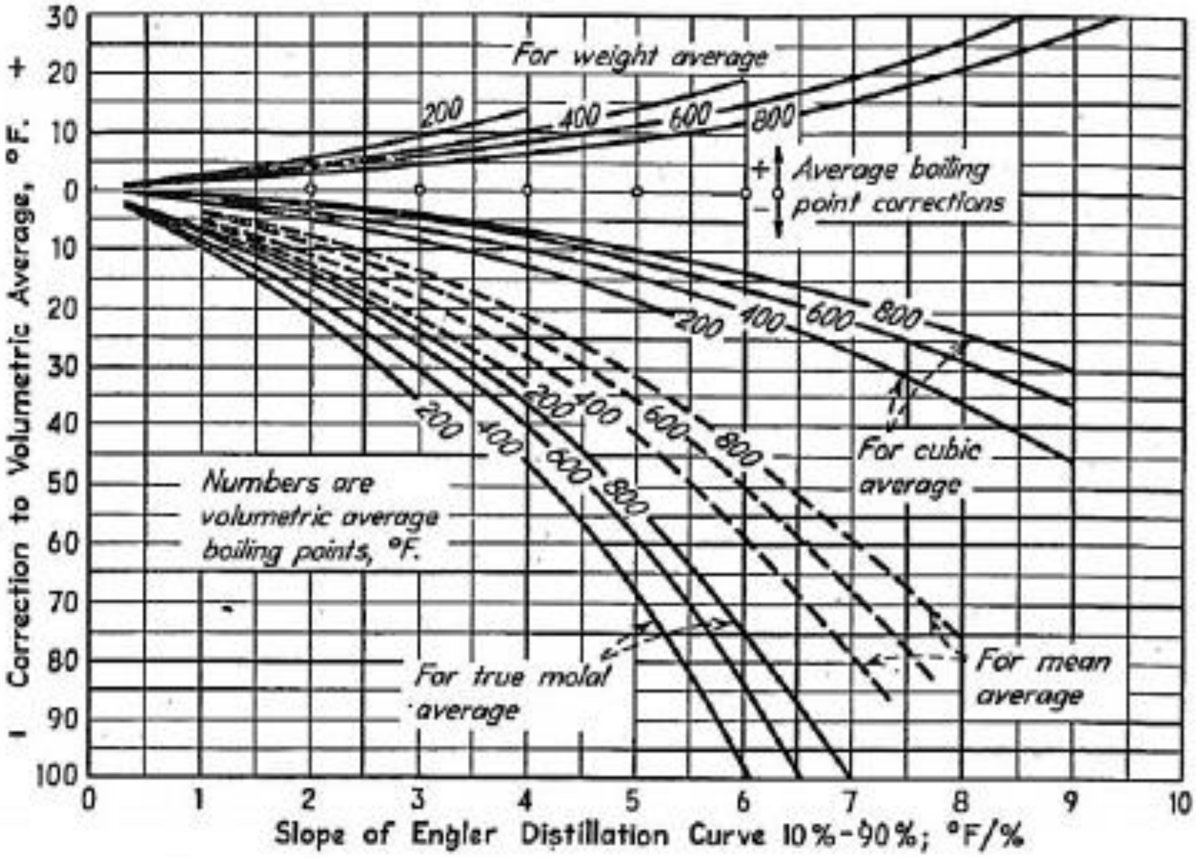


Figure (1): Characterizing Boiling Points of Petroleum Fractions

Q4: The ASTM D86 data of crude oil fraction having specific gravity of 0.720 at 60/60 °F is shown below.

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

a)Calculate VABP, also find MeABP and WABP from Figure 1.

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.

Solution

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 1. Read down from a slope of 3.465°F to the interpolated curve to 227.84 °F in the set drawn with dashed lines (MeABP). Read a correction value of -25 on the ordinate. Then find MeABP from equation below. Do the same for WABP, then read a correction of +10.

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

$$WABP = 227.84°F + 10°F = 238.84°F$$

b)

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

$M =$

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

100.264

c)

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

d) The name of the fraction is Gasoline

The API of the fraction from the calculation for gravity is 65. Using Figure (2) and the MeABP obtained from Figure (1A), a molecular weight of 100 is read off.

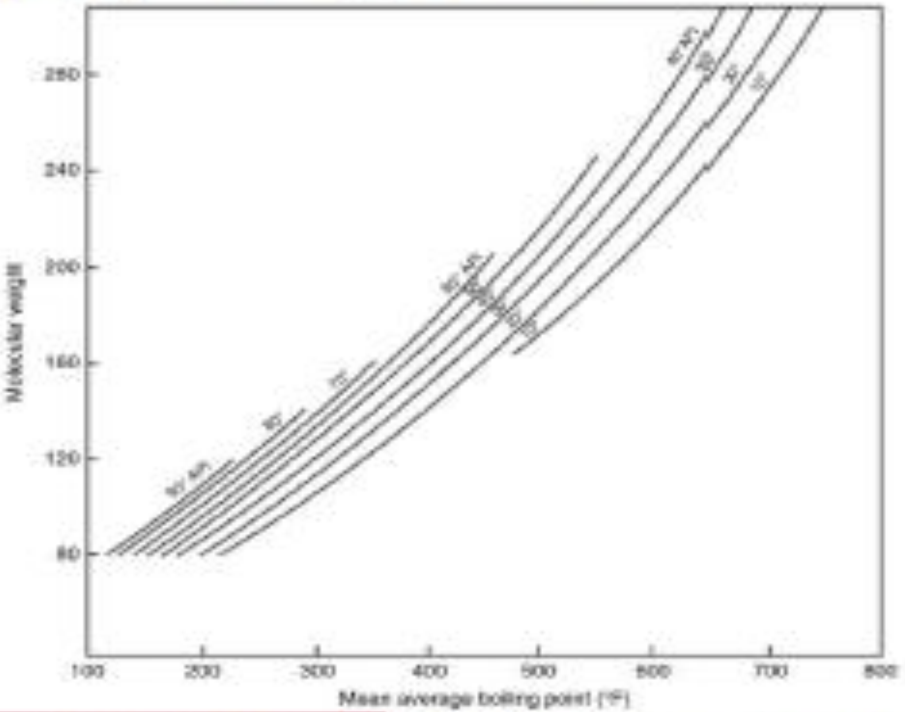


Figure (2): Correlation between boiling point, molecular weight, and gravity

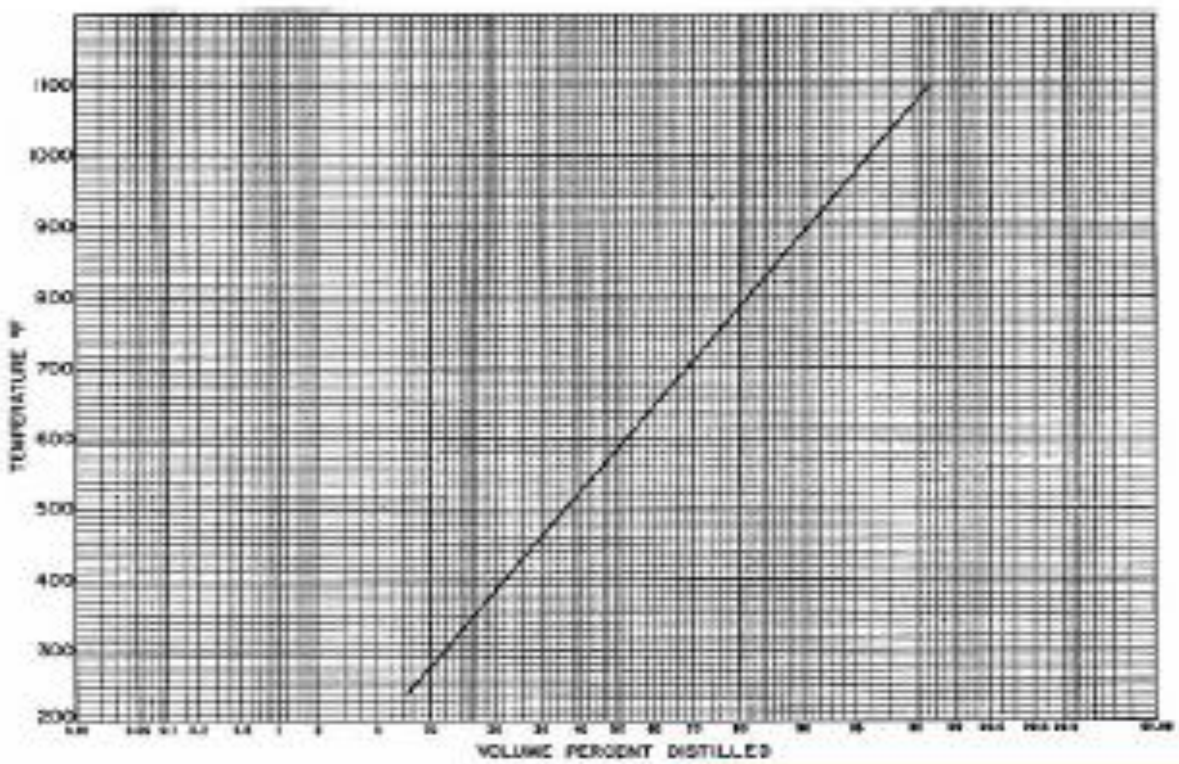


Figure (3): Crude distillation curve

Example:Consider the petroleum cut has 197-222 °C (387-432 °F) boiling range for the curve given in Figure (3).

Step 1: Volumetric range: According to the Figure (3), the volumetric range corresponding to these cuts is 20-25 i.e. vol % distilled of the fraction is 5% vol. This gives us directly the volumetric flowrate of this fraction, that is, a 5% of the total flowrate

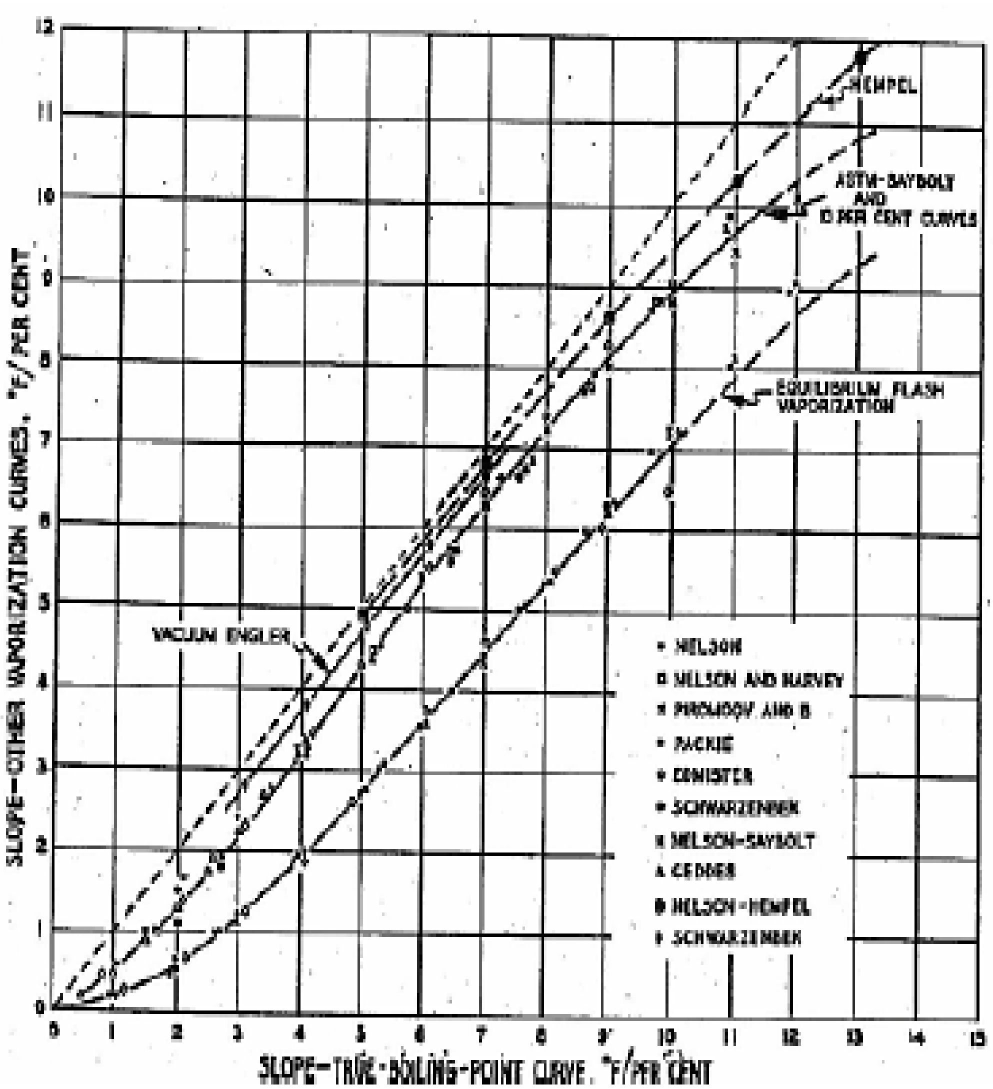


Figure (4): Relationships between the slopes of various distillation curves

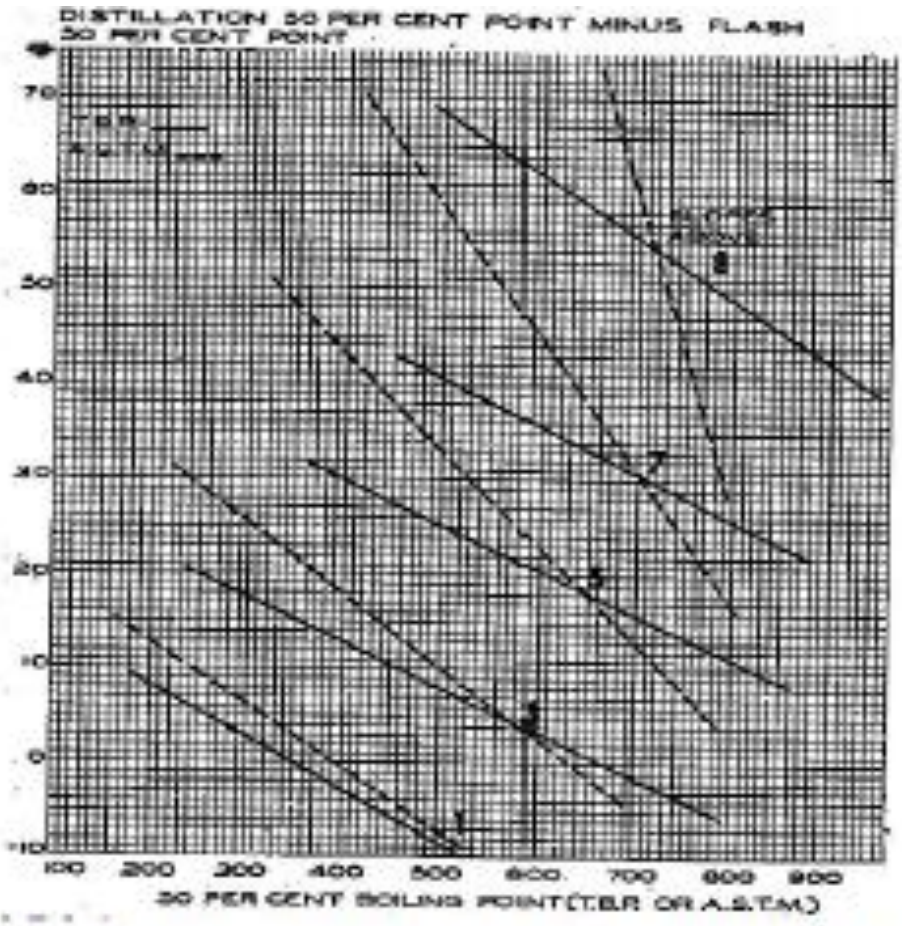


Figure (5) Relationships between distillation temperatures at 50% vaporized and the flash (E.F.V.) Temp. at 50% vol vaporized

Q5: Find $T_{100\%}$ and $T_{0\%}$ for EFV curve knowing that TBP ($T_{50\%}$ = 570 °F) and Slope = 9.4 °F

Solution

Step 1: find the EVF slope from Figure 4.

SL (EFV) = 6.5 °F

Step 2: find $T_{50\%}$ for EFV curve from TBP ($T_{50\%}$ = 570 °F) using Figure 5.

The $T_{50\%}$ of the flash curve will be about 64 °F below the $T_{50\%}$ of the TBP curve

$T_{50\%}$ EFV = 570-64=506 °F

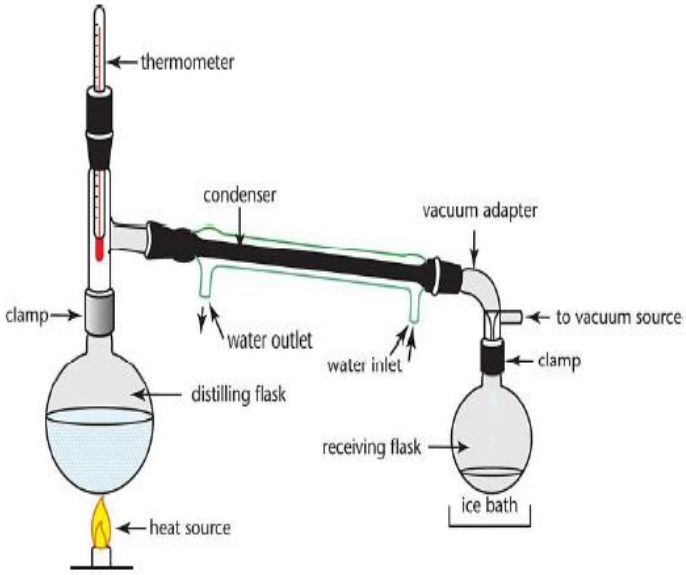
Step 3:

$$6.5 = \frac{T_{100} - 506}{50 - 0} \rightarrow T_{100} = 831°\text{F}$$

$$6.5 = \frac{506 - T_0}{100 - 50} \rightarrow T_0 = 181°\text{F}$$

ASTM D1160

- Boiling point ranges of heavy petroleum fractions such as products of a vacuum distillation column cannot be measured due to the thermal decomposition of heavy hydrocarbons at high temperatures.
- For this reason distillation data are performed at reduced pressures of 1-50 mmHg, as described under ASTM D 1160 test method.
- In this part we present calculation methods for the conversion of ASTM D 1160 to atmospheric distillation curve and for the prediction of atmospheric TBP curves from ASTM D 1160.



ASTM D1160 apparatus diagram

Conversion of a Boiling Point at Sub- or Super-Atmospheric Pressures to the Normal Boiling Point or Vice Versa.

$$T_b'(760\ mmHg) = \frac{748.1\ QT}{1 + T(0.3861Q - 0.00051606)} \ldots\ldots 1$$

Equation 1 is used to convert boiling point at sub-atmospheric (P < 760 mm Hg) or super-atmospheric (P > 760 mm Hg) conditions to normal boiling point.

$$Q = \frac{6.761560 - 0.987672 \log_{10} P}{3000.538 - 43 \log_{10} P} \qquad (P < 2\,\text{mm Hg})$$

$$Q = \frac{5.994296 - 0.972546 \log_{10} P}{2663.129 - 95.76 \log_{10} P} \qquad (2 \leq P \leq 760\,\text{mm Hg})$$

$$Q = \frac{6.412631 - 0.989679 \log_{10} P}{2770.085 - 36 \log_{10} P} \qquad (P > 760\,\text{mm Hg})$$

Where P = pressure at which boiling point or distillation data is available, mm Hg.

T = boiling point available at given pressure P, in kelvin.

T_b = normal atmospheric boiling point, in kelvin.

At P = 10 mmHg, Q = 0.001956 and as a result **Eq. (1)** reduces to the following simple form:

$$T(10mmHg) = \frac{0.683398\, T'_b}{1 - 1.63434\, x10^{-4}\, T'_b} \; .....2$$

- To use equations (1,2) for the conversion of boiling point from one low pressure to another low pressure (i.e., from 1 to 10 mm Hg), two steps are required.
- In the first step, normal boiling point or T (760 mm Hg) is calculated from T (1 mmHg) by Eq. (1) and in the second step T (10 mm Hg) is calculated from T (760 mm Hg) or T_b' via Eq. (2).