Petroleum Refinery I

[2022]

An introduction to crude oil and its processing

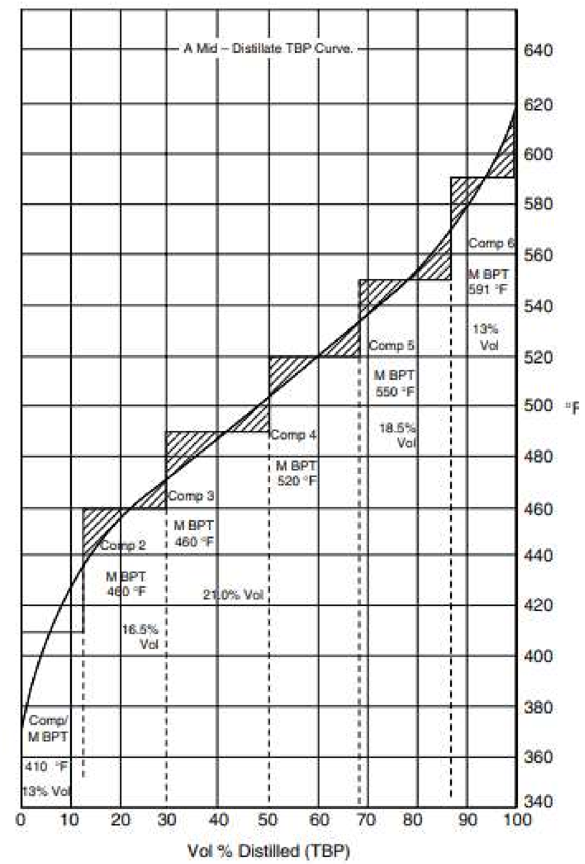
- The composition and characteristics of crude oil
- The crude oil assay
- Other basic definitions and correlations
- Predicting product qualities
- Basic processes
- The processes common to most energy refineries
- Processes not so common to energy refineries
- The non-energy refineries

The composition and characteristics of crude oil

- Crude oil is a mixture of literally hundreds of hydrocarbon compounds ranging in size from the smallest, methane, with only one carbon atom, to large compounds containing 300 and more carbon atoms.
- In order to utilize the crude oil assay it is necessary to understand the data it provides and the significance of some of the laboratory tests that are used in its compilation.

The true boiling point curve

- This curve is produced by mass spectrometry techniques much quicker and more accurately than by batch distillation. A typical true boiling point curve (TBP) is shown in Figure 1.



The ASTM distillation curve

- This type of distillation curve is used to on a routine basis for plant and product quality control. This test is carried out on crude oil fractions using a simple apparatus designed to boil the test liquid and to condense the vapors as they are produced. Vapor temperatures are noted as the distillation proceeds and are plotted against the distillate recovered. Because only one equilibrium stage is used and no reflux is returned, the separation of components is poor. Thus, the initial boiling point (IBP) for ASTM is higher than the corresponding TBP point and the final boiling point (FBP) of the ASTM is lower than that for the TBP curve. There is a correlation between the ASTM and the TBP curve.

API gravity

- This is an expression of the density of an oil. Unless stated otherwise the API gravity refers to density at 60◦F (15.6◦C). Its relationship with specific gravity is given by the expression

$$\text{API}^\circ = \frac{141.5}{\text{sp.gr.}} - 131.5$$

Flash points

- The flash point of an oil is the temperature at which the vapor above the oil will momentarily flash or explode. This temperature is determined by laboratory testing using an apparatus consisting of a closed cup containing the oil, heating and stirring equipment, and a special adjustable flame.
- The type of apparatus used for middle distillate and fuel oils is called the Pensky Marten (PM), while the apparatus used in the case of Kerosene and lighter distillates is called the Abel. Reference to these tests are given later in this Handbook, and full details of the tests methods and procedures are given in ASTM Standards Part 7, Petroleum products and Lubricants.
- There are many empirical methods for determining flash points from the ASTM distillation curve. One such correlation is given by the expression

$$\text{Flash point } ^\circ\text{F} = 0.77\,(\text{ASTM } 5\% \ ^\circ\text{F} - 150^\circ\text{F})$$

Octane numbers

- Octane numbers are a measure of a gasoline's resistance to knock or detonation in a cylinder of a gasoline engine. *The higher this resistance* is the higher will be the efficiency of the fuel to produce work. A relationship exists between the antiknock characteristic of the gasoline (octane number) and the compression ratio of the engine in which it is to be used.
- The higher the octane rating of the fuel then the higher the compression ratio of engine in which it can be used.
- By definition, an octane number is that percentage of isooctane in a blend of isooctane and normal heptane that exactly matches the knock behavior of the gasoline. Thus, a 90 octane gasoline matches the knock characteristic of a blend containing 90% isooctane and 10% n-heptane.

Viscosity

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Cloud and pour points

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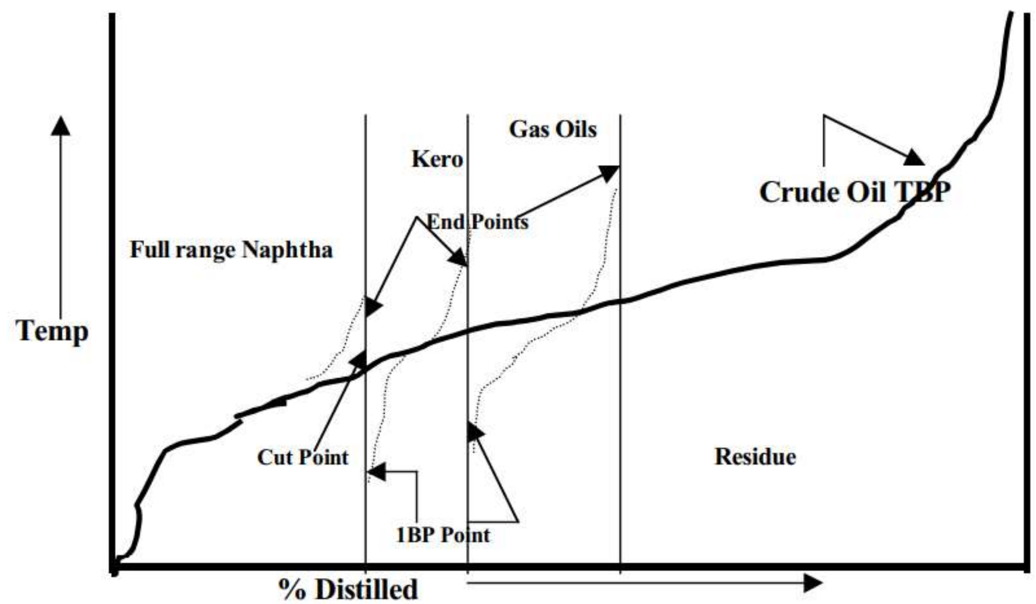
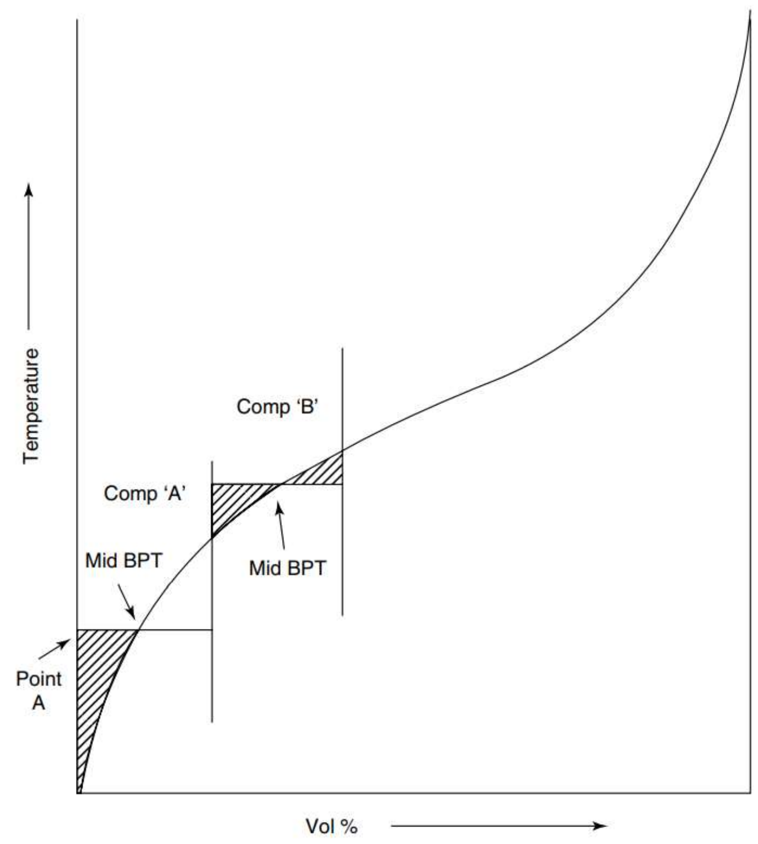


A fraction with an upper cut point of 100◦F produces a yield of 20% volume of the whole crude as that fraction. The next adjacent fraction has a lower cut point of 100◦F and an upper one of 200◦F this represents a yield of 30–20% = 10% volume on crude

Mid boiling point components

- Draw a horizontal line through this from the 0% volume. Extend the line until the area between the line and the curve on both sides of the temperature point A are equal
- The length of the horizontal line measures the yield of component A having a mid boiling point A ◦F. Repeat for the next adjacent component and continue until the whole curve is divided into these mid boiling point components.



Good, Connel et al Method:

- Good, Connel et al accumulated data to relate the ASTM end point to a TBP cut point the light and middle distillate range of crude.
- Their correlation are shown in the figure 1 beside :
- Thrift derived a probable shape of ASTM data. As shown in figure 2 beside:
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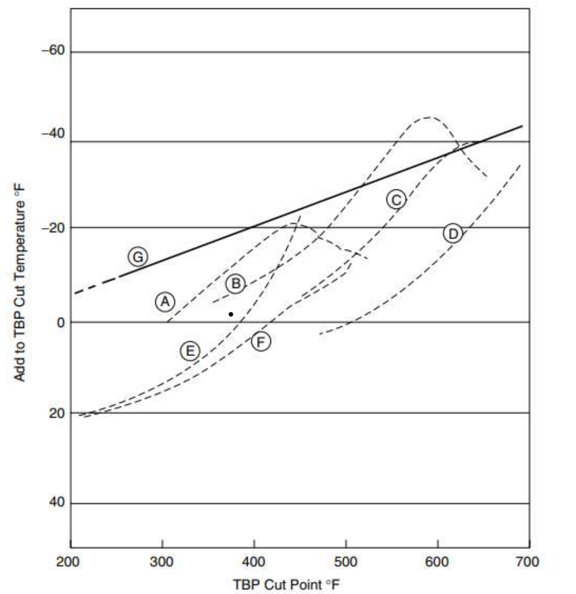
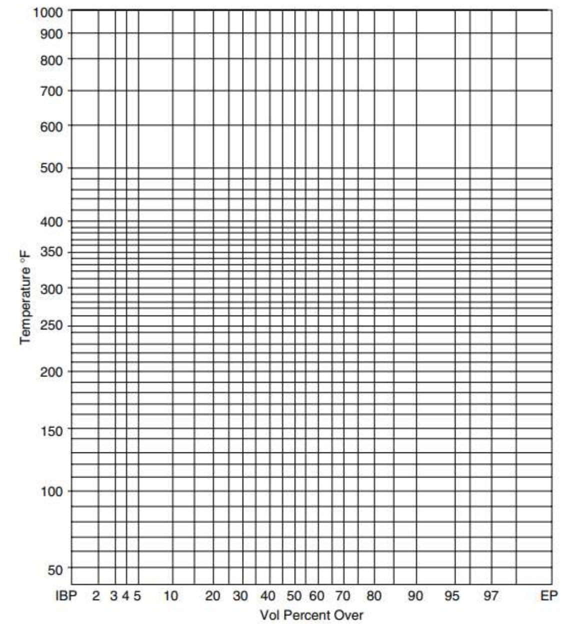


A End Points Vs TBP Cut Point for fractions starting at 200°F TBP or Lower
B End Points Vs TBP Cut Point for fractions starting at 300
C End Points Vs TBP Cut Point for fractions starting at 400
D End Points Vs TBP Cut Point for fractions starting at 500
E & F ASTM End Points Vs TBP Cut Point 300 ml STD col & 5 ft Packed Towers.
G 90% vol temp Vs 90% vol TBP cut (All Fractions).

Figure 1 Correlation between TBP and ASTM end points.



ASTM distillation probability curves.

https://www.youtube.com/watch?v=ZCiRfq9d_PA

Predicting TBP and ASTM curves from assay data

- The properties of products can be predicted by constructing mid boiling point components from a TBP curve and assigning the properties to each of these components.
- These assigned properties are obtained either from the assay data, known components of similar boiling points, or established relationships such as gravity, molecular weights, and boiling points.

Mid-volume percentage point components

- This is easier than the mid boiling point concept and requires only that the curve be divided into a number of volumetric sections. The mid volume figure for each of these sections is merely the arithmetic mean of the volume range of each component.

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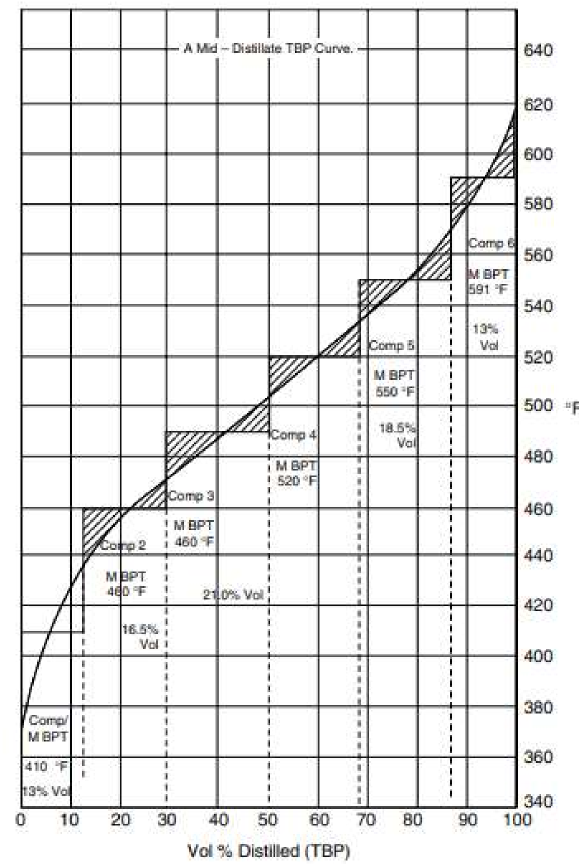

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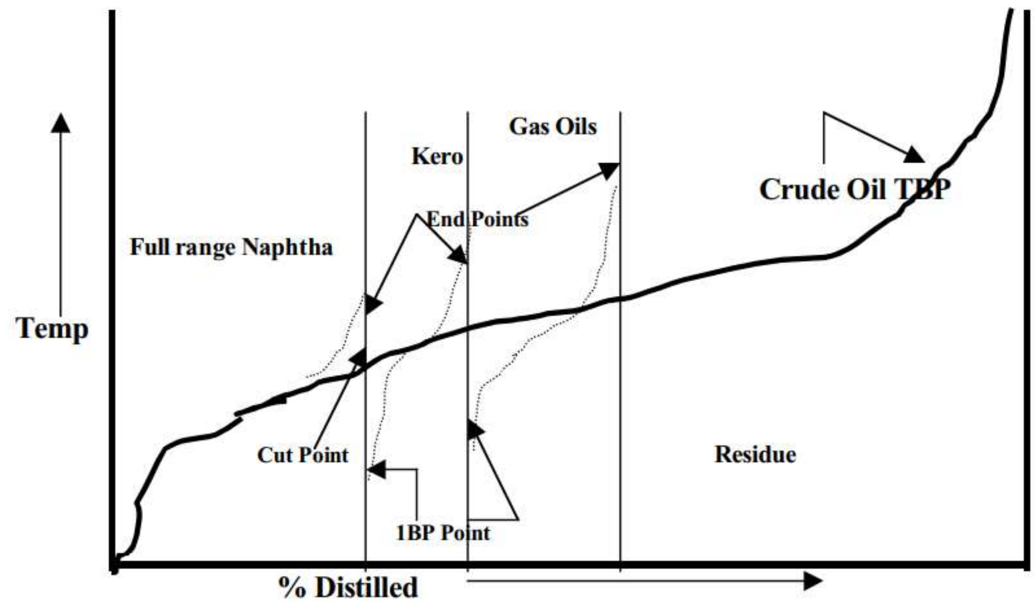

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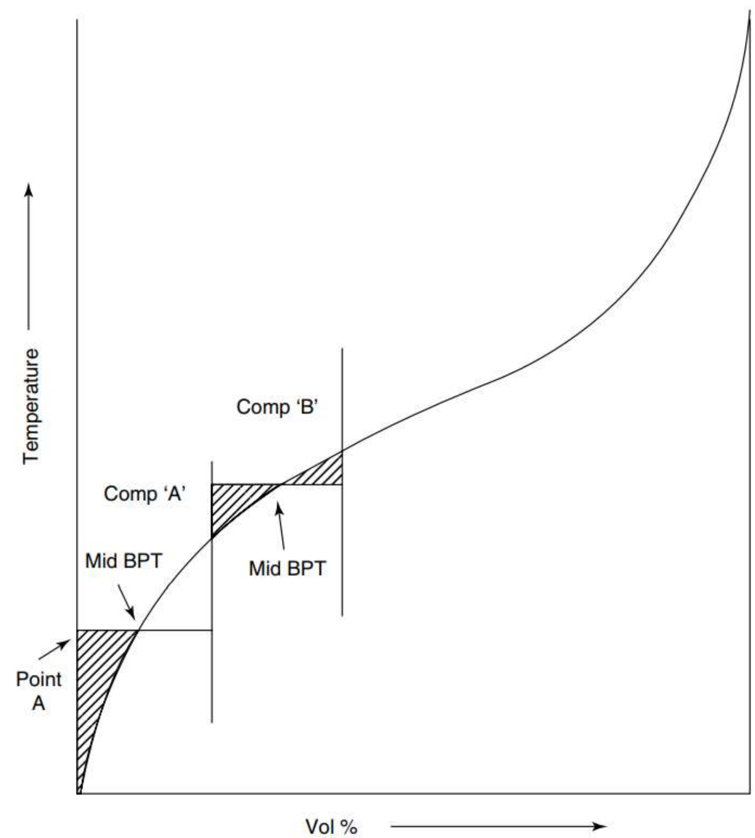

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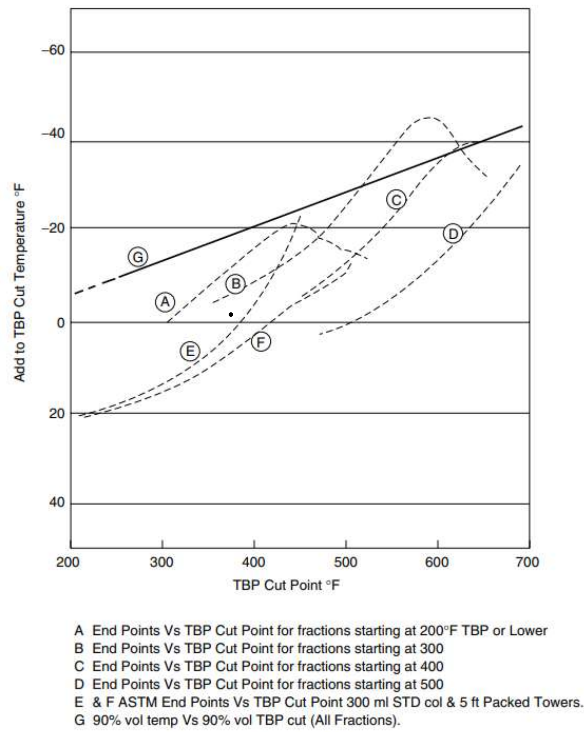

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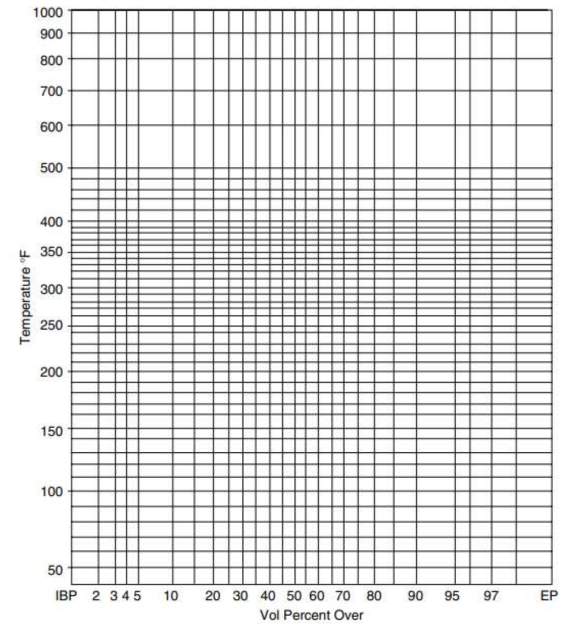

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