



Properties of Reservoir Fluids (PGE 362)

Quantitative Phase Behavior

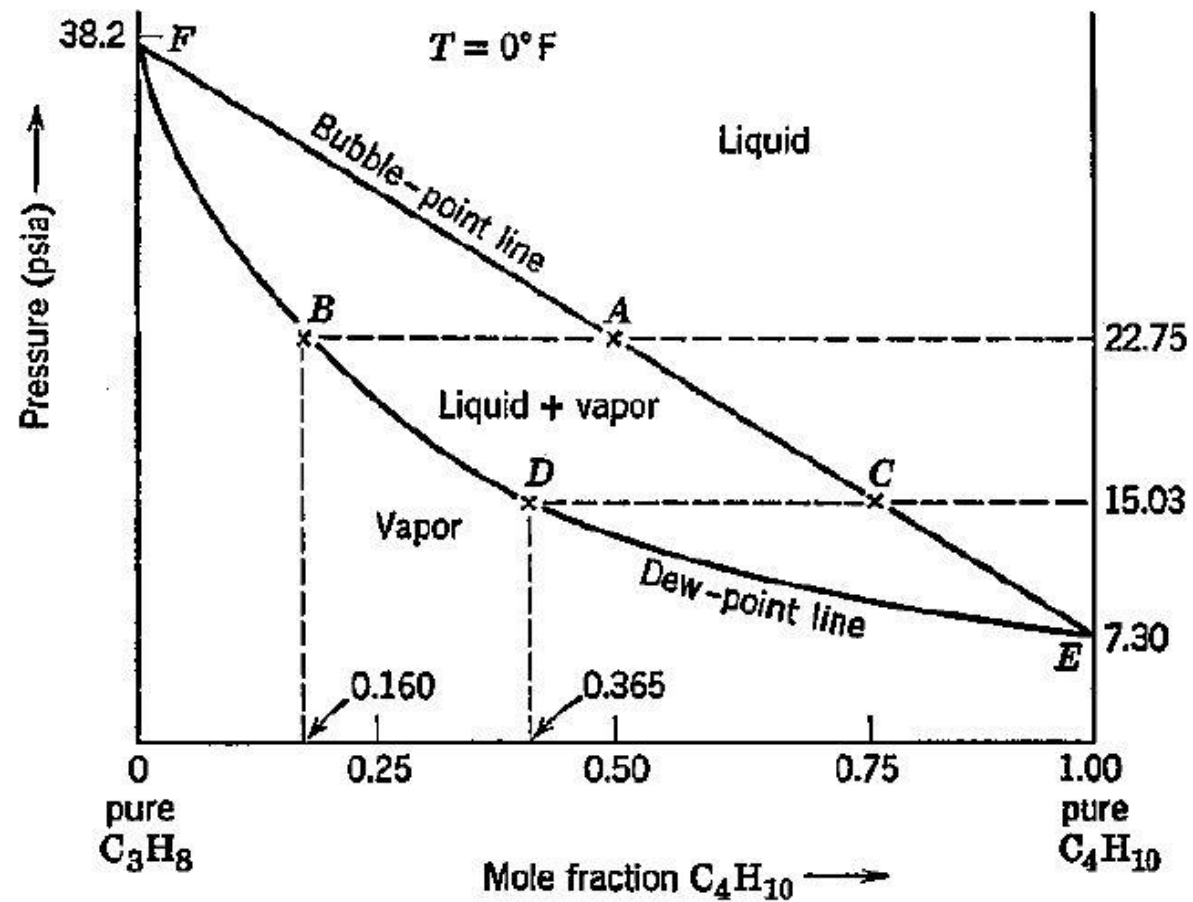
BY
DR. MOHAMMED A. KHAMIS
29-11-2016

Ideal Solutions

From the previous example (L11):

Component	P_i^0	x_i	$P_i = x_i P_i^0$	$y_i = P_i / P_T$
C_3H_8	38.20	0.50	19.10	0.840
C_4H_{10}	7.30	0.50	3.65	0.160
			$P_T = 22.75 \text{ psia}$	
Component	P_i^0	x_i	$P_i = x_i P_i^0$	$y_i = P_i / P_T$
C_3H_8	38.20	0.25	9.55	0.635
C_4H_{10}	7.30	0.75	5.48	0.365
			$P_T = 15.03 \text{ psia}$	

Ideal Solutions



Ideal Solutions

Why bubble point is a straight line:

Bubble point line is a linear function of composition.

$$BPP = x_1 P_1^\circ + x_2 P_2^\circ$$

Since $x_1 = 1 - x_2$ for a **binary system**,

$$BPP = (P_1^\circ - P_2^\circ) x_1 + P_2^\circ$$

$$y = ax + b$$

Ideal Solutions

Calculation of the liquid and vapor composition of two-component system in the two phase region:

Application of Raoult's Law:

$$P_T = x_1 P_1^\circ + x_2 P_2^\circ$$

x_1 and x_2 : mole fraction of the two components in the **liquid** (generally, do not represent the overall composition of the system).

$$x_2 = 1 - x_1$$

$$P_T = x_1 P_1^\circ + (1 - x_1) P_2^\circ$$

Ideal Solutions

Solving for x_1 :

$$x_1 = \frac{P_T - P_2^\circ}{P_1^\circ - P_2^\circ}$$

$$x_2 = \frac{P_T - P_1^\circ}{P_2^\circ - P_1^\circ}$$

If **Dalton's Law** is applicable to the vapor,

$$y_1 = \frac{P_1}{P_T} = \frac{x_1 P_1^\circ}{P_T}$$

$$y_2 = \frac{P_2}{P_T} = \frac{x_2 P_2^\circ}{P_T}$$

Ideal Solutions

Example:

Assuming **ideal solution behavior** calculate the composition of the liquid and vapor at **180° F** and **95 psia** for a system containing **one mole** of **n-butane** and **one mole** of **n-pentane**.

The vapor pressure of pure components at **180° F** are **160 psia** for **C₄H₁₀** and **54 psia** for **C₅H₁₂**. (Properties of petroleum reservoir fluids: **Burcik** – Appendix B)

Ideal Solutions

Solution:

$$x_{C_4H_{10}} = \frac{P_T - P_{C_5H_{12}}^{\circ}}{P_{C_4H_{10}}^{\circ} - P_{C_5H_{12}}^{\circ}} = \frac{95 - 54}{160 - 54} = \mathbf{0.3868}$$

$$x_{C_5H_{12}} = 1 - x_{C_4H_{10}} = 1 - 0.394 = \mathbf{0.6132}$$

$$y_{C_4H_{10}} = \frac{x_{C_4H_{10}} P_{C_4H_{10}}^{\circ}}{P_T} = \frac{0.3868 \times 160}{95} = \mathbf{0.6515}$$

$$y_{C_5H_{12}} = 1 - y_{C_4H_{10}} = 1 - 0.665 = \mathbf{0.3485}$$

Ideal Solutions

Calculation of the dew point pressure of a two-component system:

At dew point the system is essentially all vapor except for tiny amount of liquid.

$$y_1 = \frac{x_1 P_1^\circ}{P_T}$$
$$x_1 = \frac{P_T - P_2^\circ}{P_1^\circ - P_2^\circ}$$

$$y_1 = \frac{\frac{P_T - P_2^\circ}{P_1^\circ - P_2^\circ} P_1^\circ}{P_T}$$

$$P_T = \frac{-P_2^\circ}{\frac{y_1}{P_1^\circ} [P_1^\circ - P_2^\circ] - 1}$$

Ideal Solutions

Example:

Assuming **ideal solution behavior** calculate the dew-point pressure and the composition of the liquid at the dew-point at **180° F** for a system containing **one mole** of **n-butane** and **one mole** of **n-pentane**.

The vapor pressure of pure components at **180° F** are **160 psia** for C_4H_{10} and **54 psia** for C_5H_{12} .

Ideal Solutions

Solution:

$$y_{C_4H_{10}} = \frac{\frac{P_T - P_{C_5H_{12}}^\circ}{P_{C_4H_{10}}^\circ - P_{C_5H_{12}}^\circ} P_{C_4H_{10}}^\circ}{P_T}$$

$$0.5 = \frac{\frac{P_T - 54}{160 - 54} 160}{P_T}$$

$$P_T = 80.8 \text{ psia} = \text{DPP}$$

Ideal Solutions

Solution:

The composition of the liquid at the dew point;

$$x_{C_4H_{10}} = \frac{P_T - P_{C_5H_{12}}^\circ}{P_{C_4H_{10}}^\circ - P_{C_5H_{12}}^\circ}$$

$$x_{C_4H_{10}} = \frac{80.8 - 54}{160 - 54} = \mathbf{0.2528}$$

$$x_{C_5H_{12}} = 1 - x_{C_4H_{10}} = 1 - 0.2528 = \mathbf{0.7472}$$

Ideal Solutions

Solution:

The bubble point pressure;

$$x_{C_4H_{10}} = \frac{P_T - P_2^\circ}{P_1 - P_2^\circ} \quad 0.5 = \frac{P_T - 54}{160 - 54}$$

$$P_T = 107 \text{ psia} = \text{BPP}$$

$$y_{C_4H_{10}} = \frac{x_{C_4H_{10}} P_{C_4H_{10}}^\circ}{P_T} \quad y_{C_4H_{10}} = \frac{0.5 \times 160}{107} = 0.7477$$

$$y_{C_5H_{12}} = 1 - x_{C_4H_{10}} = 1 - 0.7477 = 0.2523$$

Ideal Solutions

Solution:

1. BBP = 107 psia
 2. Composition of vapor at BBP ($y_{C_4H_{10}} = 0.7477$, $y_{C_5H_{12}} = 0.2523$)
 3. Composition of liquid vapor at 95 psia ($x_{C_4H_{10}} = 0.3868$, $x_{C_5H_{12}} = 0.6132$,
 $y_{C_4H_{10}} = 0.6515$, $y_{C_5H_{12}} = 0.3485$)
-
1. DPP = 80.8 psia
 2. Composition of liquid at DPP ($x_{C_4H_{10}} = 0.2528$, $x_{C_5H_{12}} = 0.7472$)

Ideal Solutions

Solution:

