جامعة الملك سعود
King Saud University

كلية الهندسة
جامعة الملك سعود
King Saud University
College Of Engineering

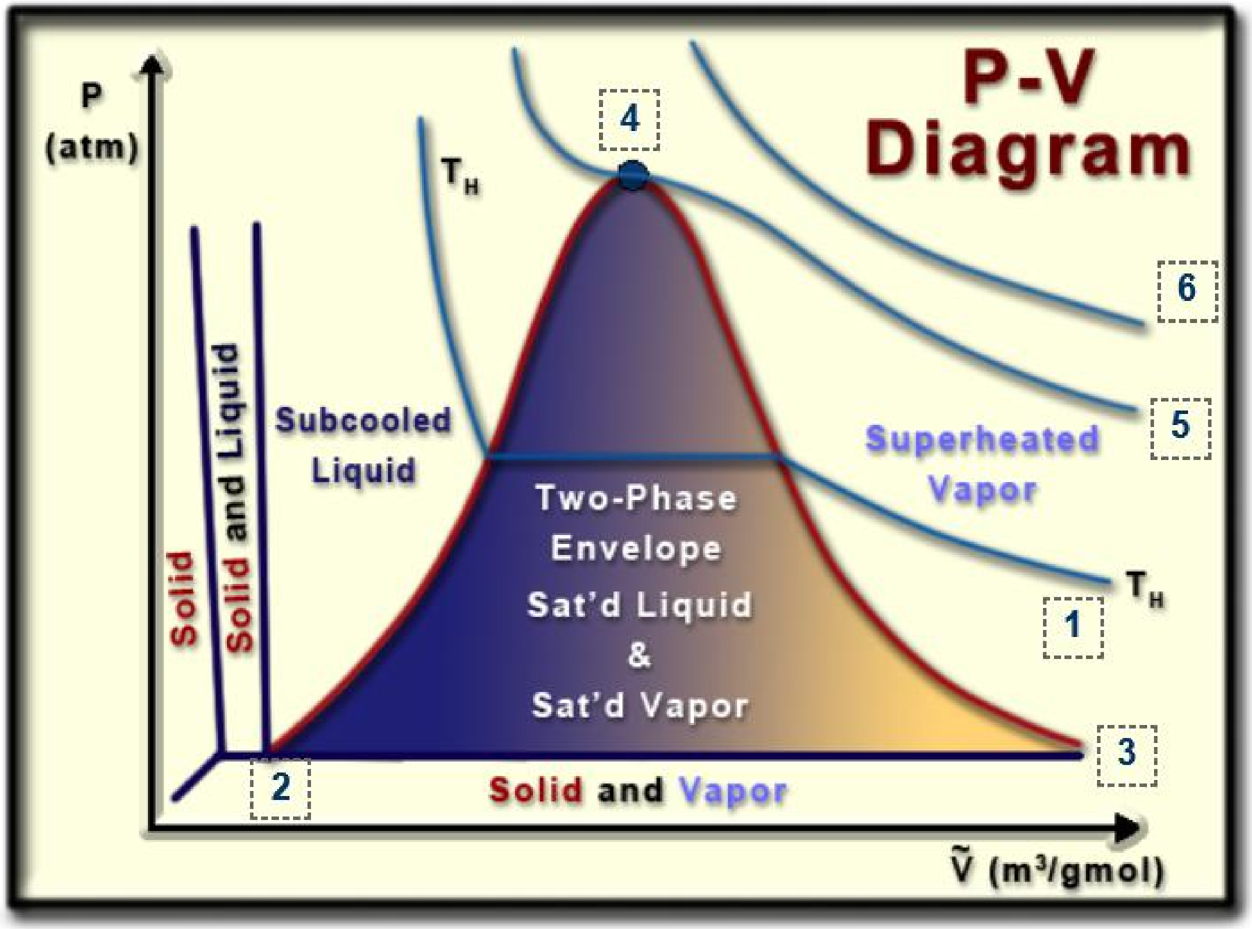
Properties of Reservoir Fluids (PGE 362)

Phase Behavior of Liquids

BY
DR. MOHAMMED A. KHAMIS
26-03-2017

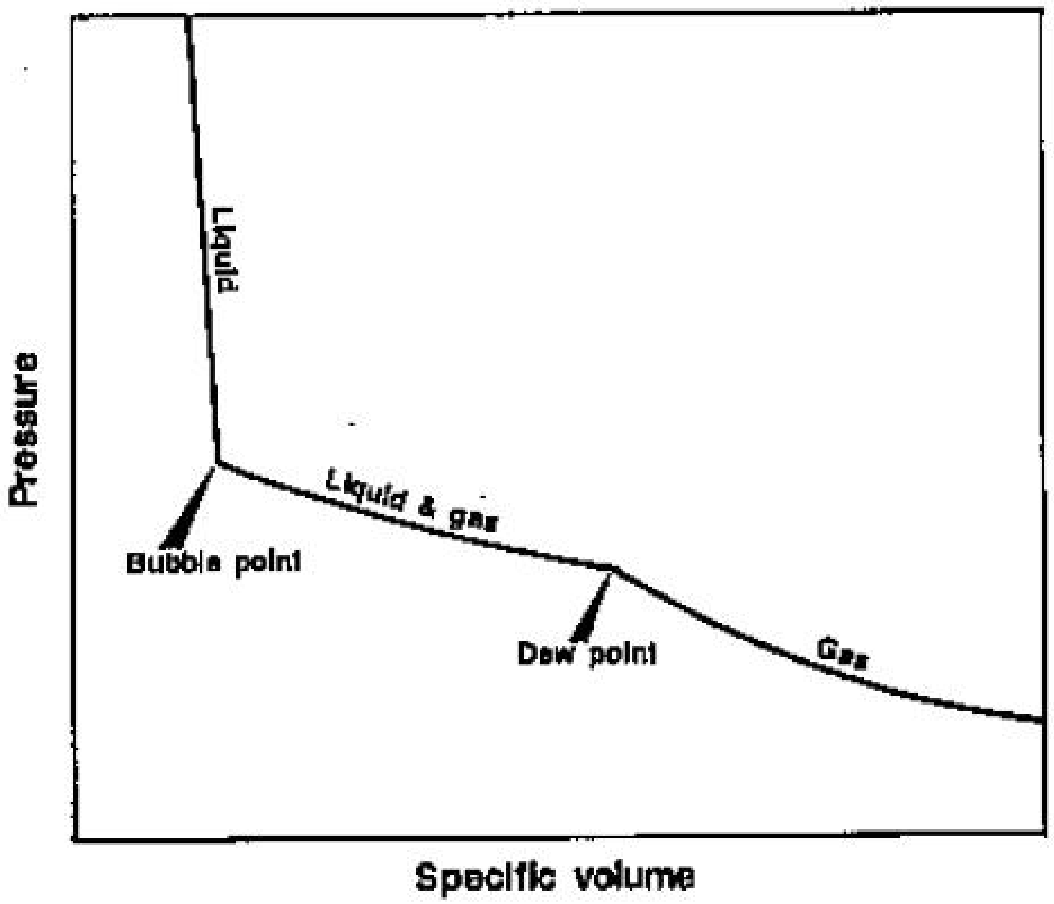
Pressure-Volume diagram

1. Isotherm curve
   - Constant temp. < Tc
1. Saturated liquid curve
2. Saturated vapor curve
3. Critical point
   - Saturated liquid and vapor are identical T=Tc
1. Critical isotherm curve
   - T=Tc
1. Supercritical isotherm curve
   - T > Tc



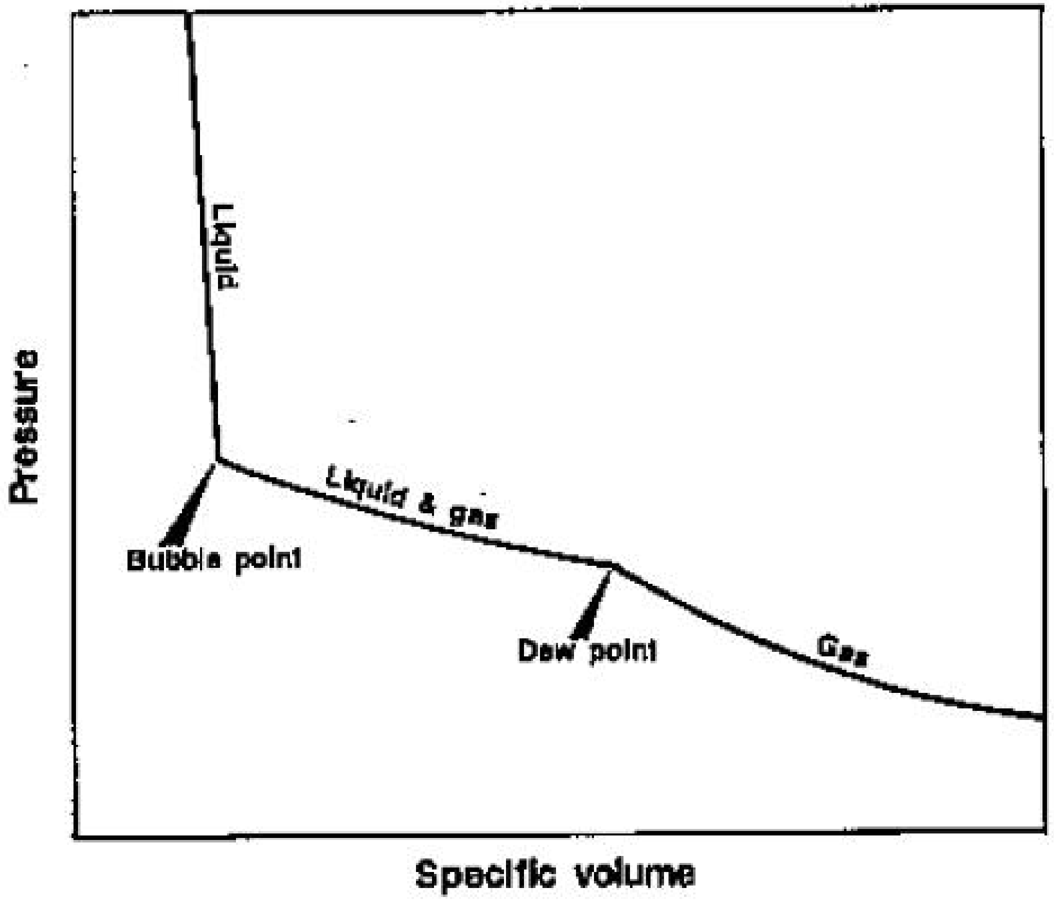
Pressure-Volume diagram of Two Component System

1. Vapor phase
2. Liquid phase
3. Two phase region
    1. Different from “isotherm of pure substance”



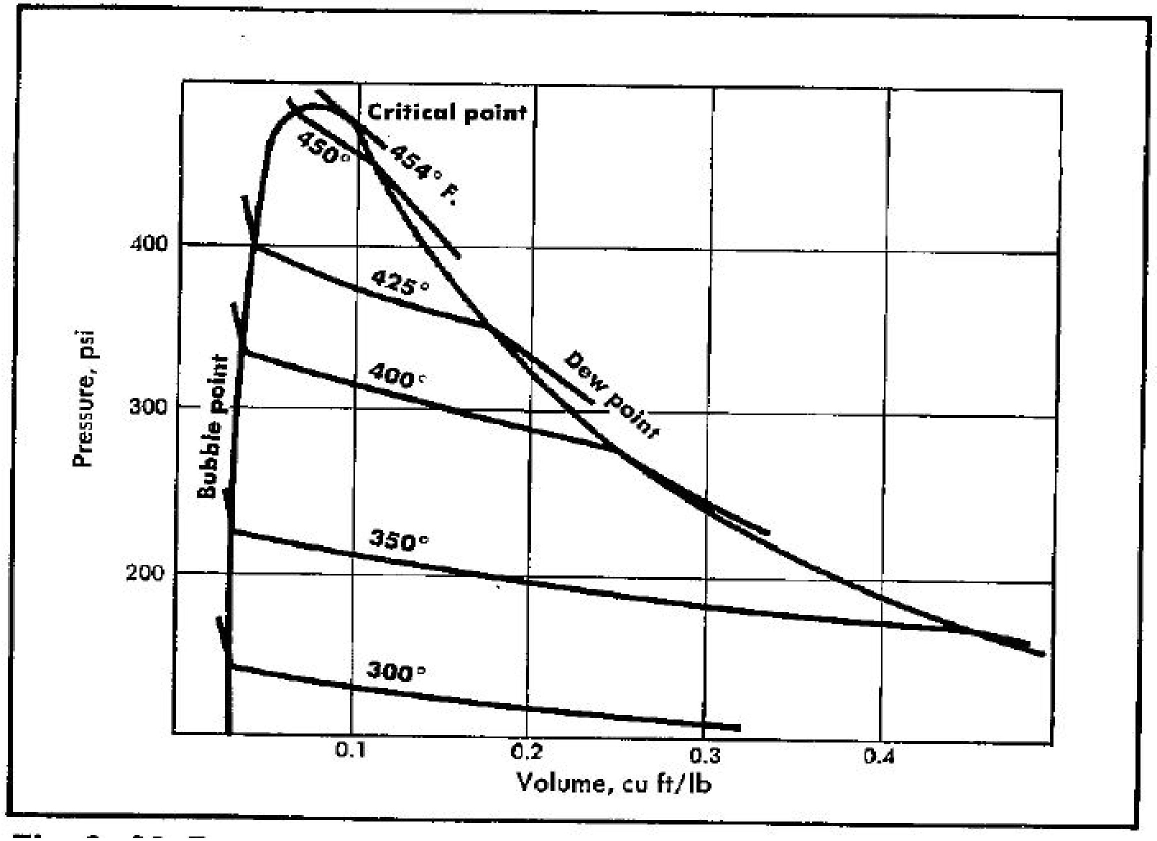
Pressure-Volume diagram of Two Component System

1. At dew point
   a. Composition of the vapor = composition of the system.
   b. Infinitesimal (tiny) amount of liquid that condense is richer in the less volatile component.
2. At bubble point
   a. Infinitesimal amount of vapor remaining is richer in the more volatile component than the system as a whole.

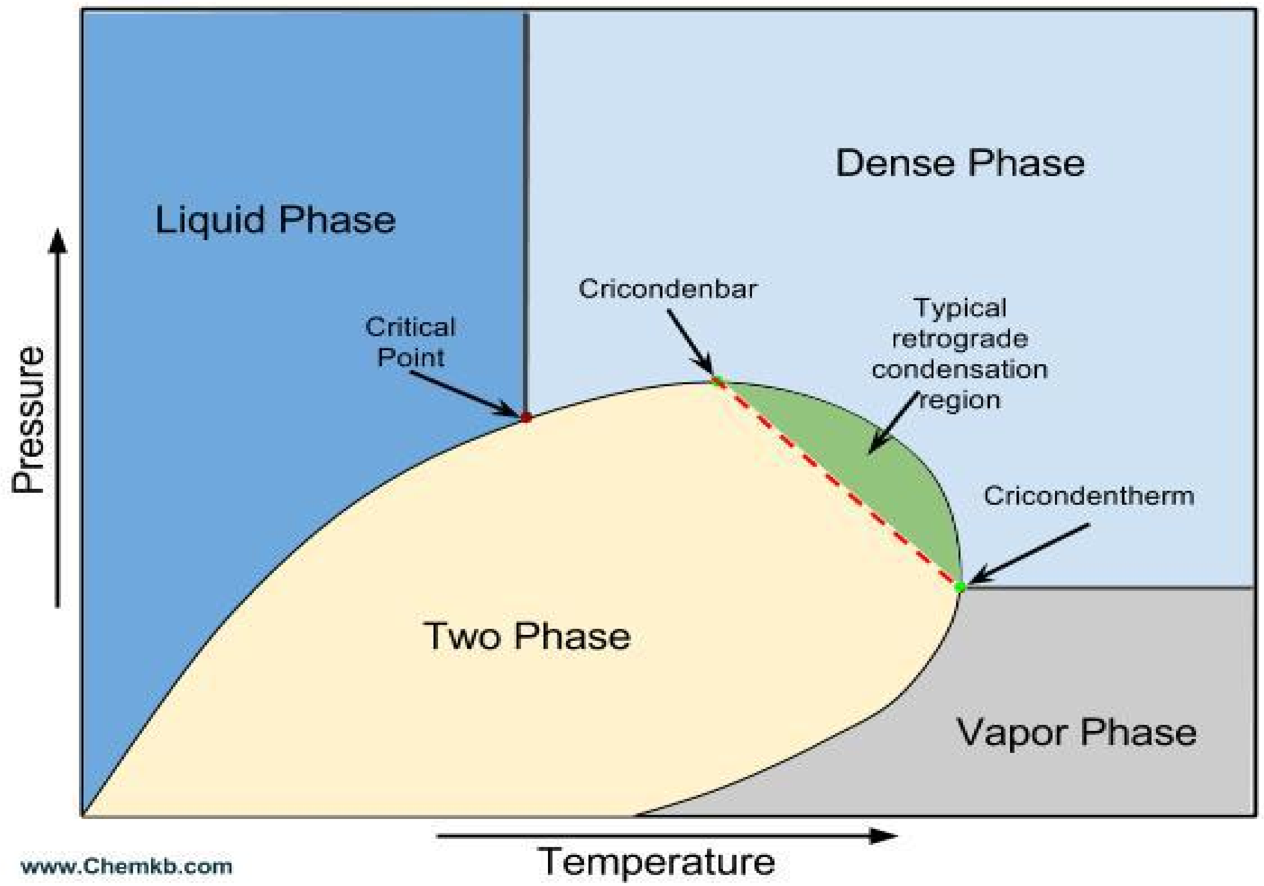


Pressure-Volume diagram of Two Component System

1. Isotherm curves (n-pentane 52 w-% , n-heptane system)
2. Critical point?
   a. The vapor can exist at P > Pc
   b. Liquid can exist at T > Tc.



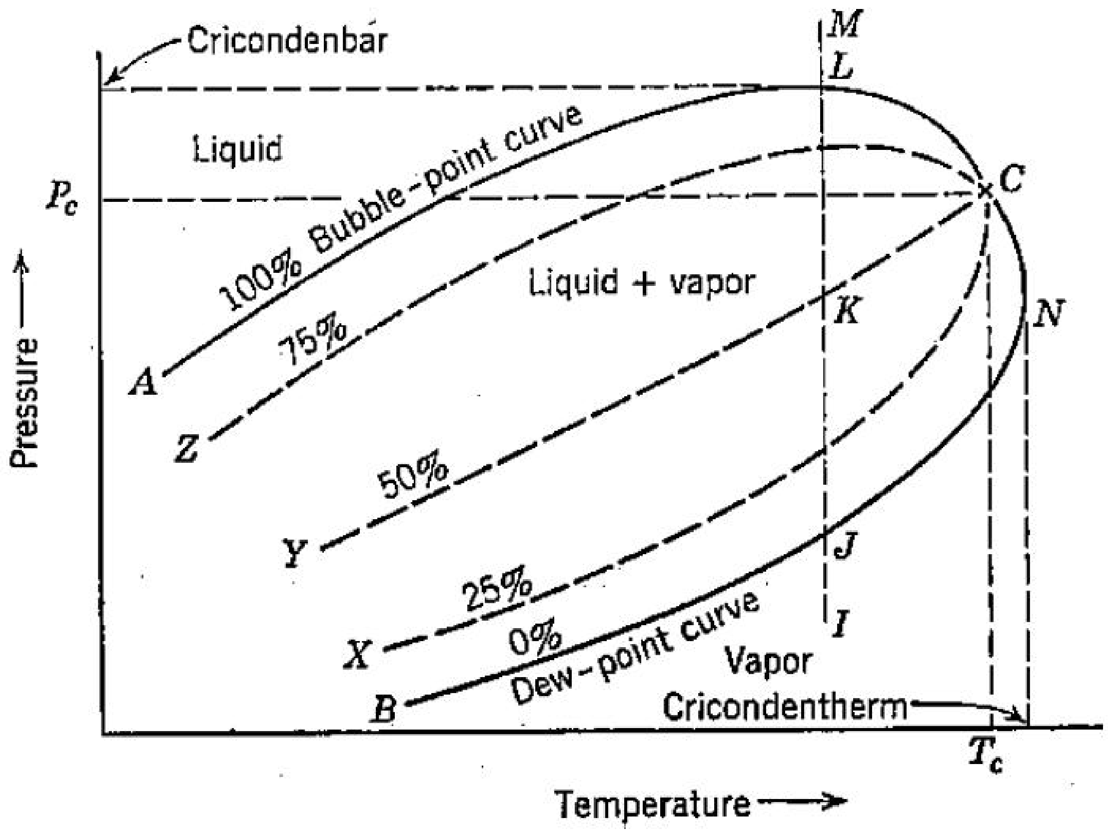
Pressure-Temperature diagram of Two Component System



Pressure-Temperature diagram of Two Component System

1. AC: Bubble point
2. BC: Dew point
3. C: Critical point
4. L: Cricondenbar (Pcb)?
    - Cricondenbar temperature (Tcb).

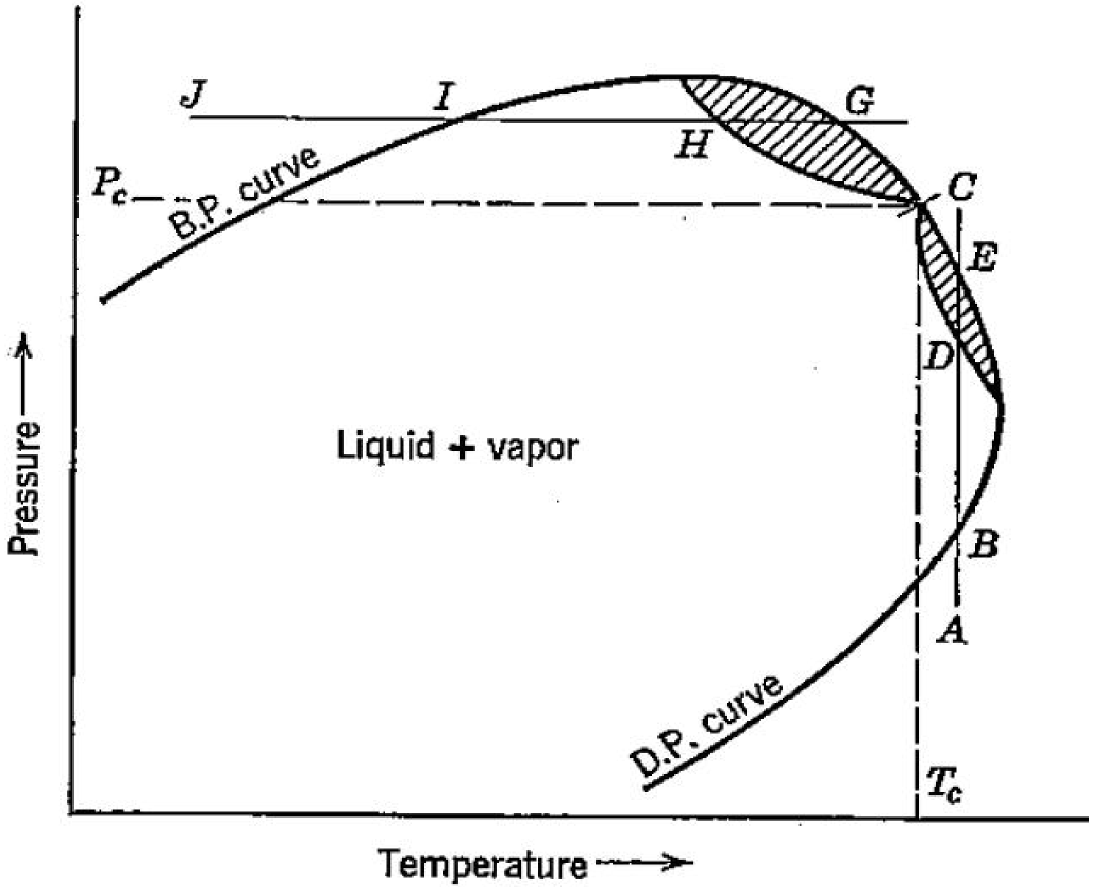
1. N: Cricondentherm (Tct)?
    - Cricondertherm pressure (Pct).



Pressure-Temperature diagram of Two Component System

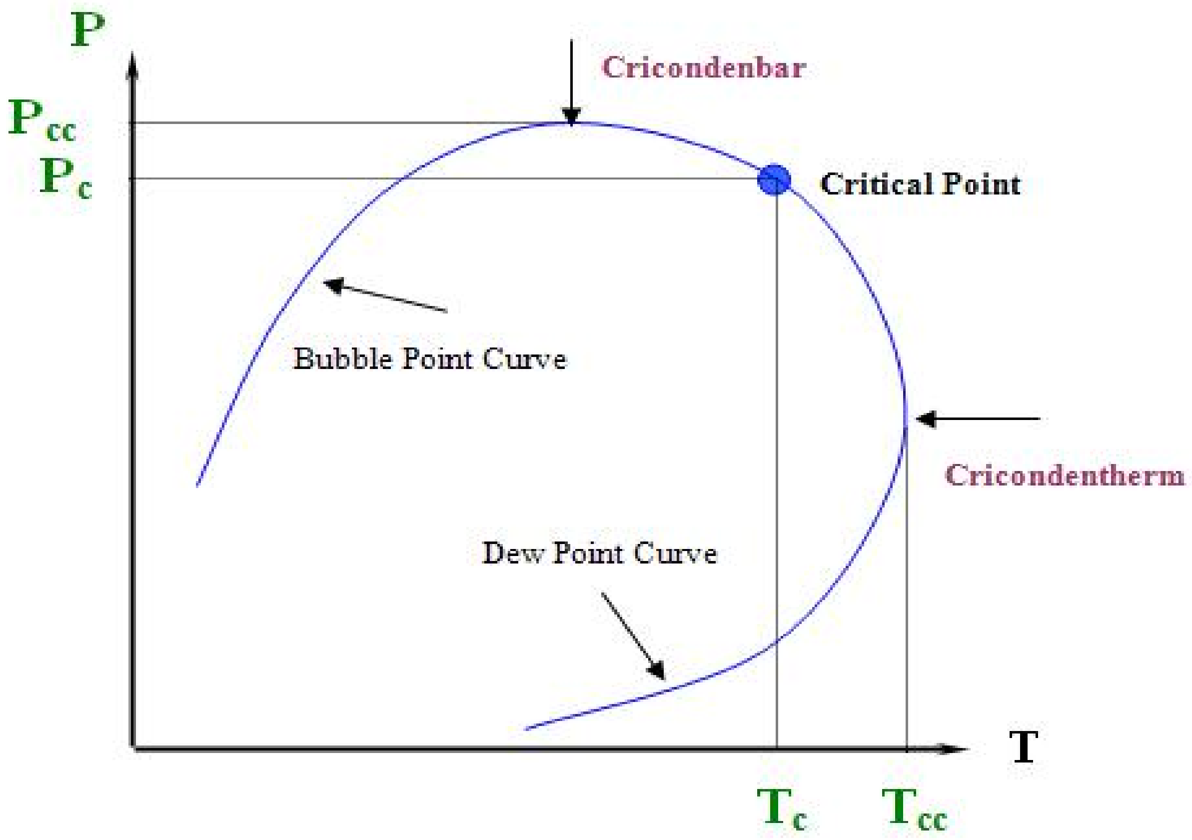
Retrograde phenomenon:

- D-E: isothermal retrograde vaporization.
- E-D: isothermal retrograde condensation
- H-G: isobaric retrograde condensation
- G-H: isobaric retrograde vaporization



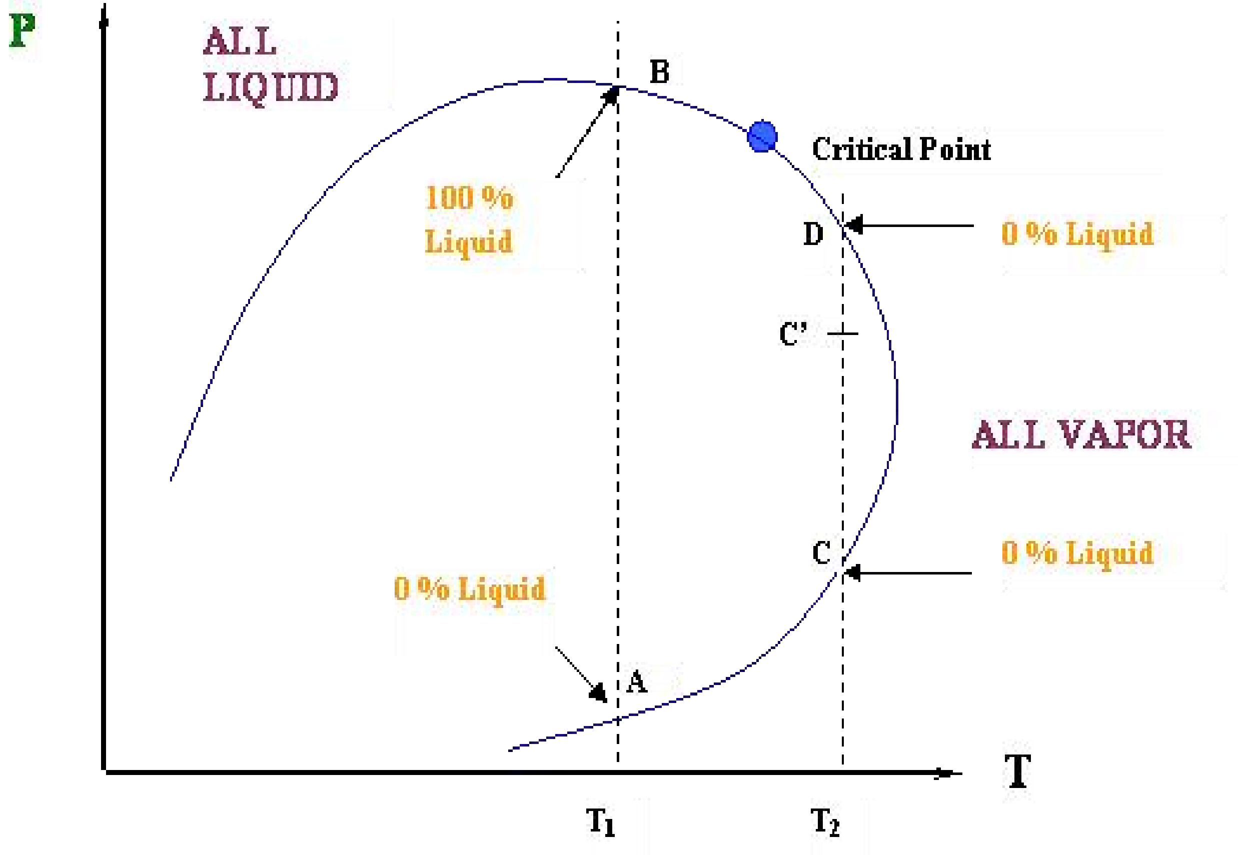
Retrograde Phenomenon

- Pc
- Pcc
- Tc
- Tcc



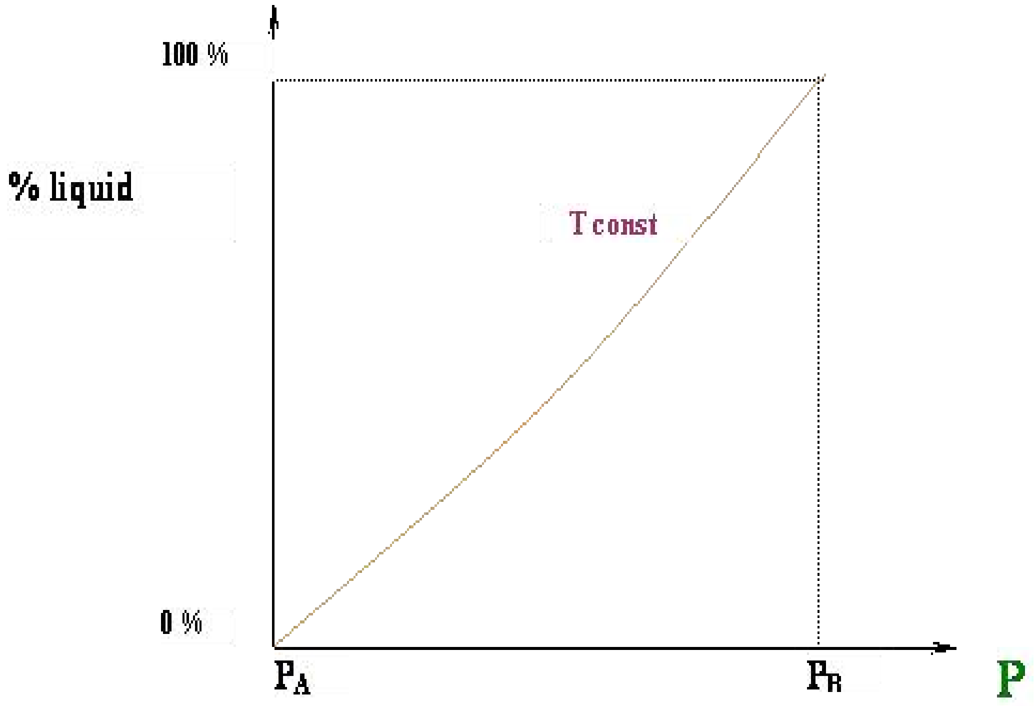
Retrograde Phenomenon

1. Line A-B @ T_1 (T_1 <Tc)
2. Line C-C'-D @ T_2 (T_2 >Tc)



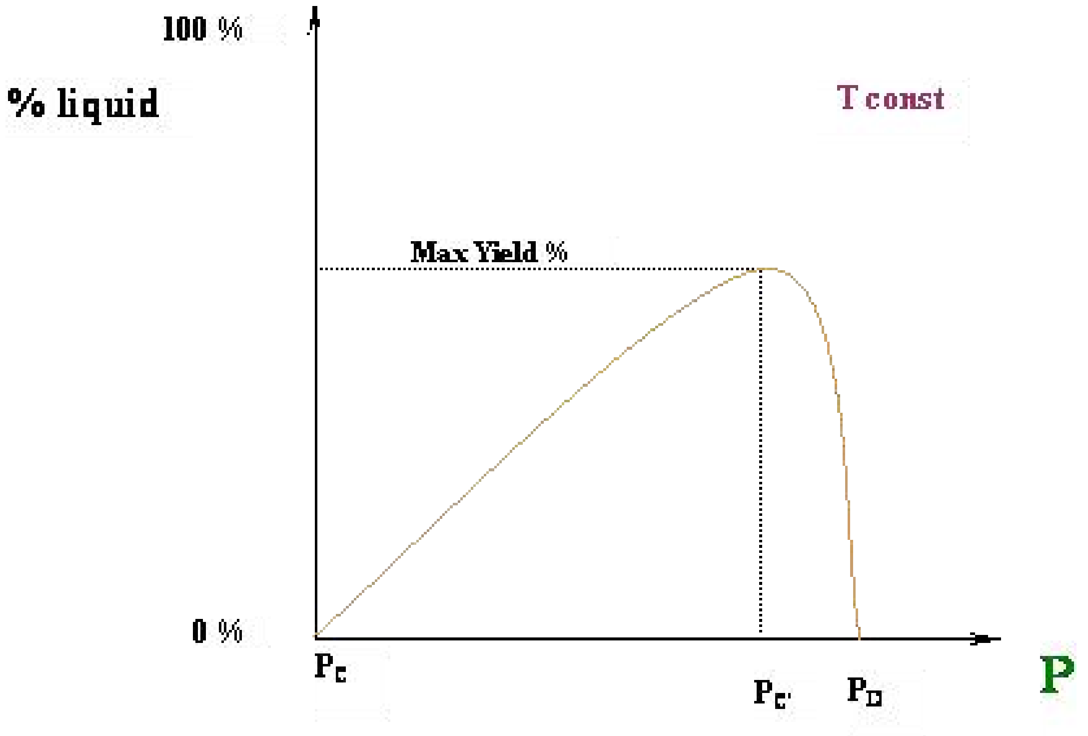
Retrograde Phenomenon

1. Line A-B
   - 0% liquid to 100%



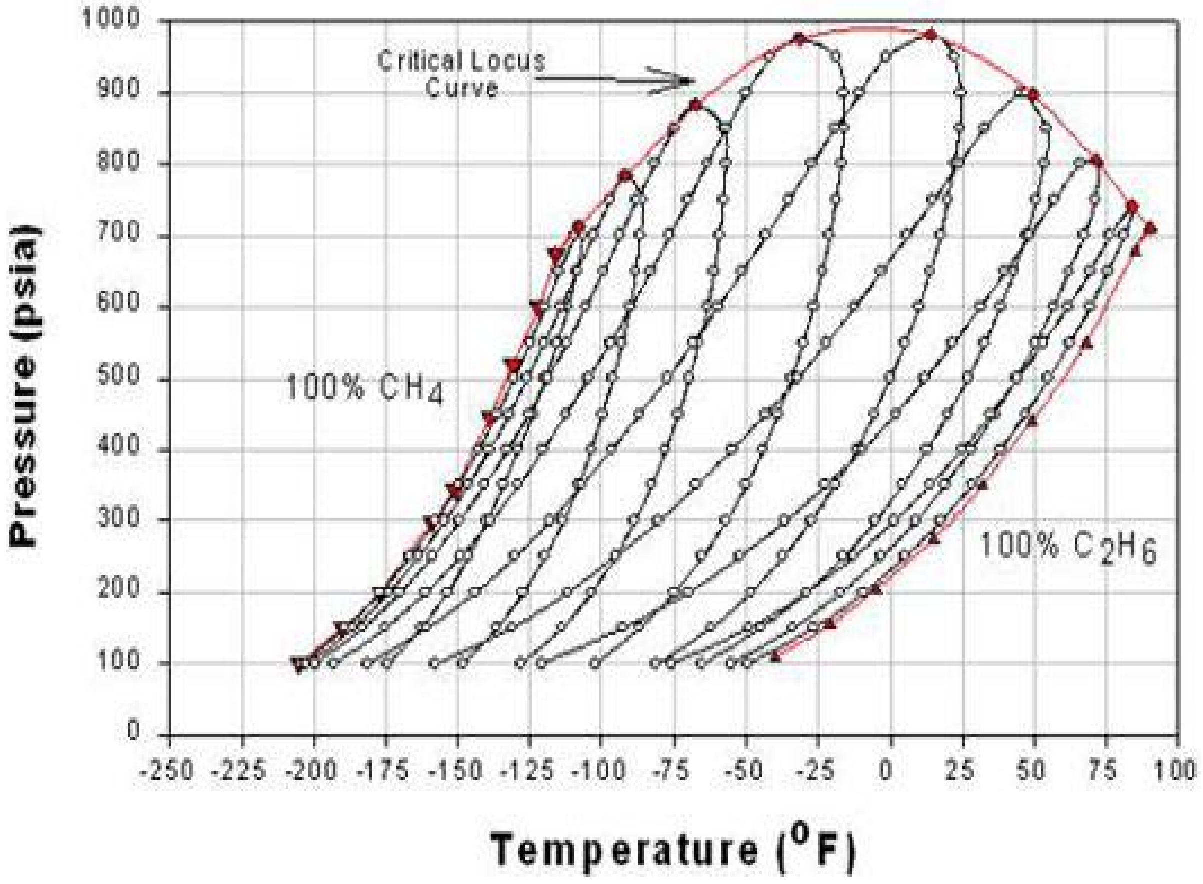
Retrograde Phenomenon

2. Line C-C'-D
   - 0% liquid to Max. Yield



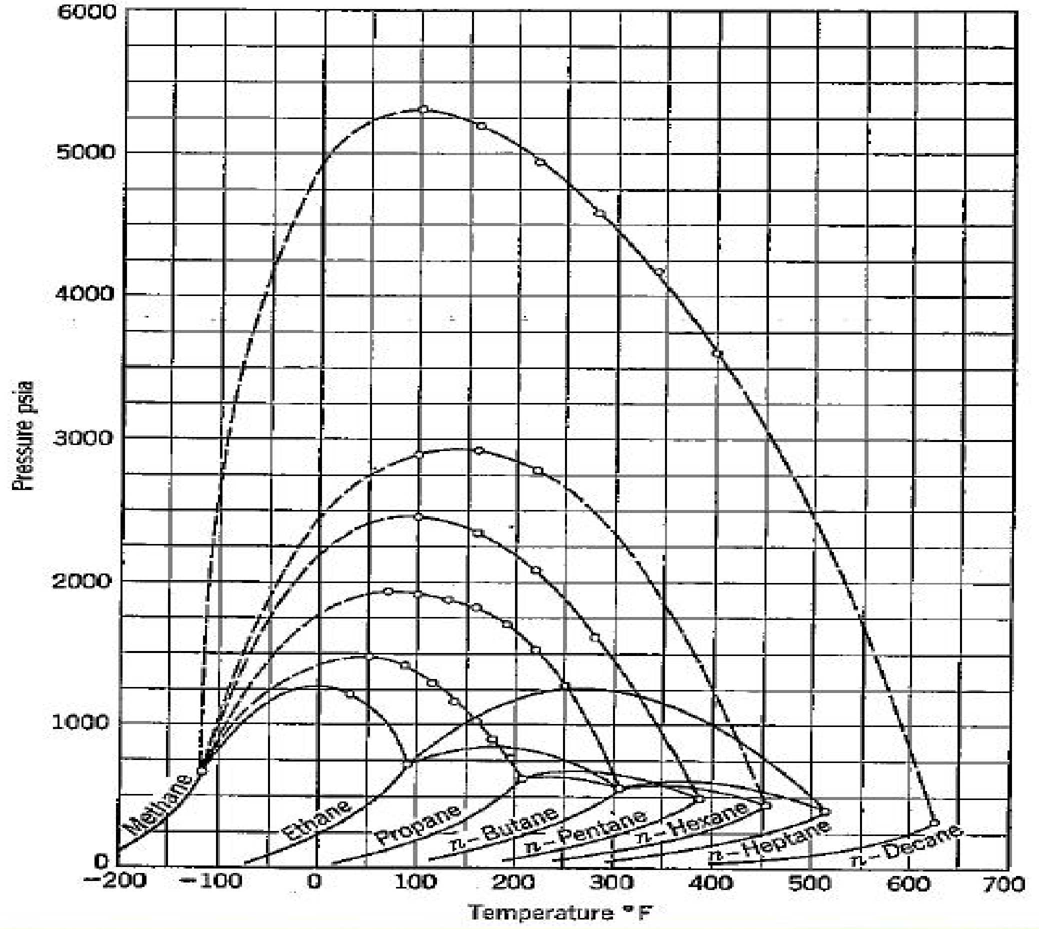
The Composite P-T diagram of methane & ethane

1. Eight mixtures of methane-ethane
2. Vapor pressure lines of pure methane and pure ethane.
3. Critical pressure of the mixtures lie above the critical pressures of the pure components.
4. Critical temperature?
5. The effect of the mixtures similarities or dissimilarities on the critical locus curve?



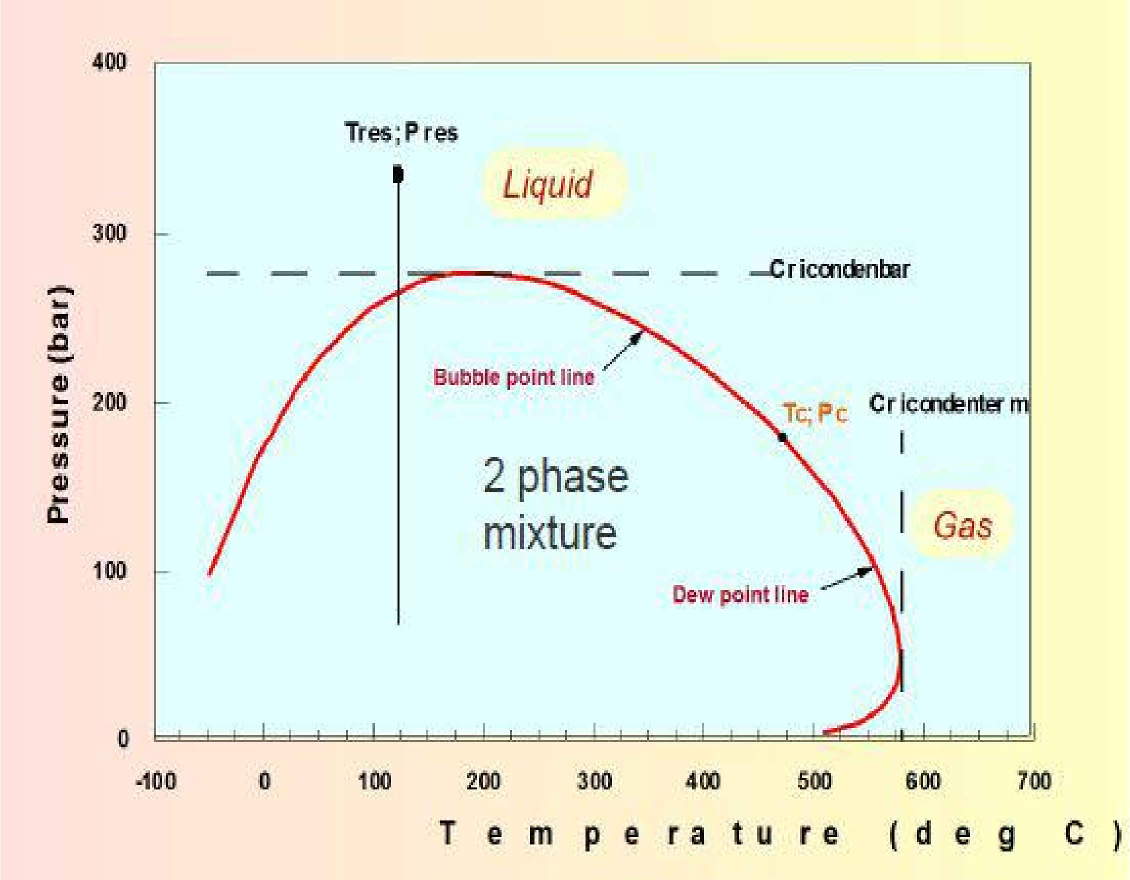
The Composite P-T diagram of n-paraffin mixtures

1. The critical pressures of mixtures are higher tan those of the components of the mixtures
2. Higher difference in molecular size of the components cause the mixtures to have very large critical pressures.



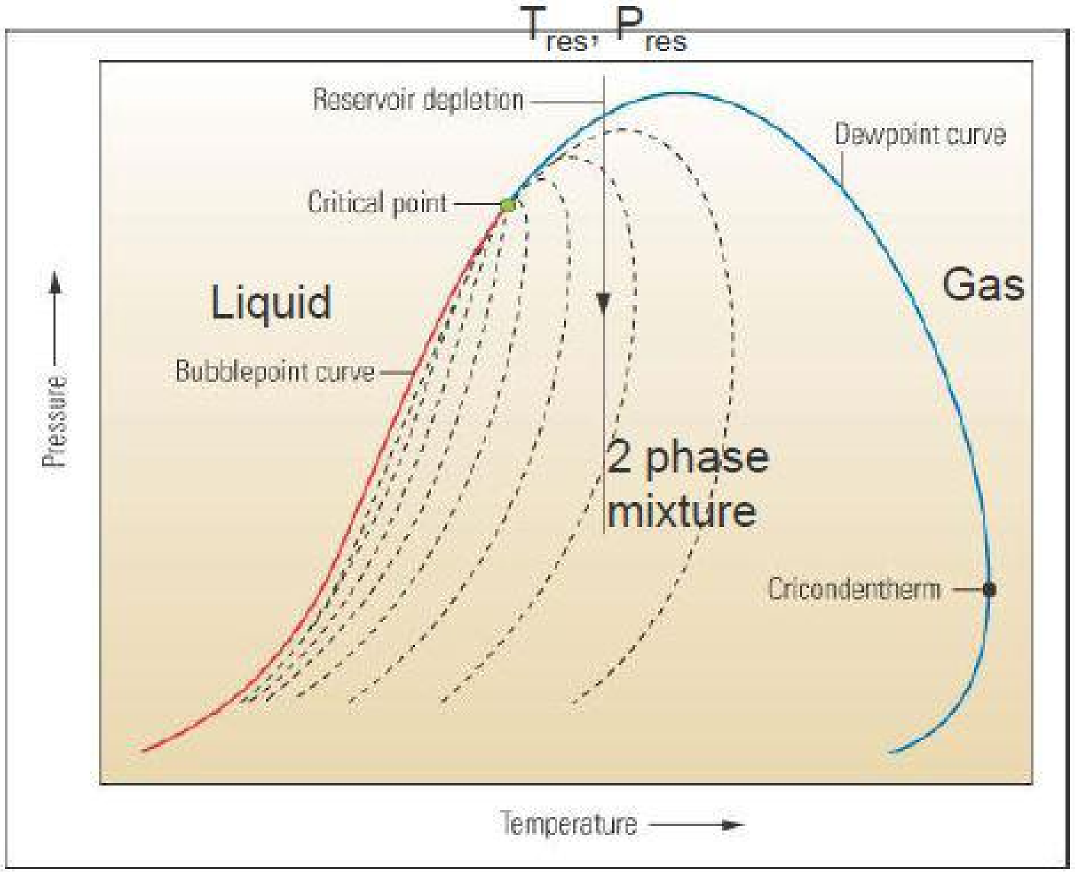
Examples

1. Gas condensate



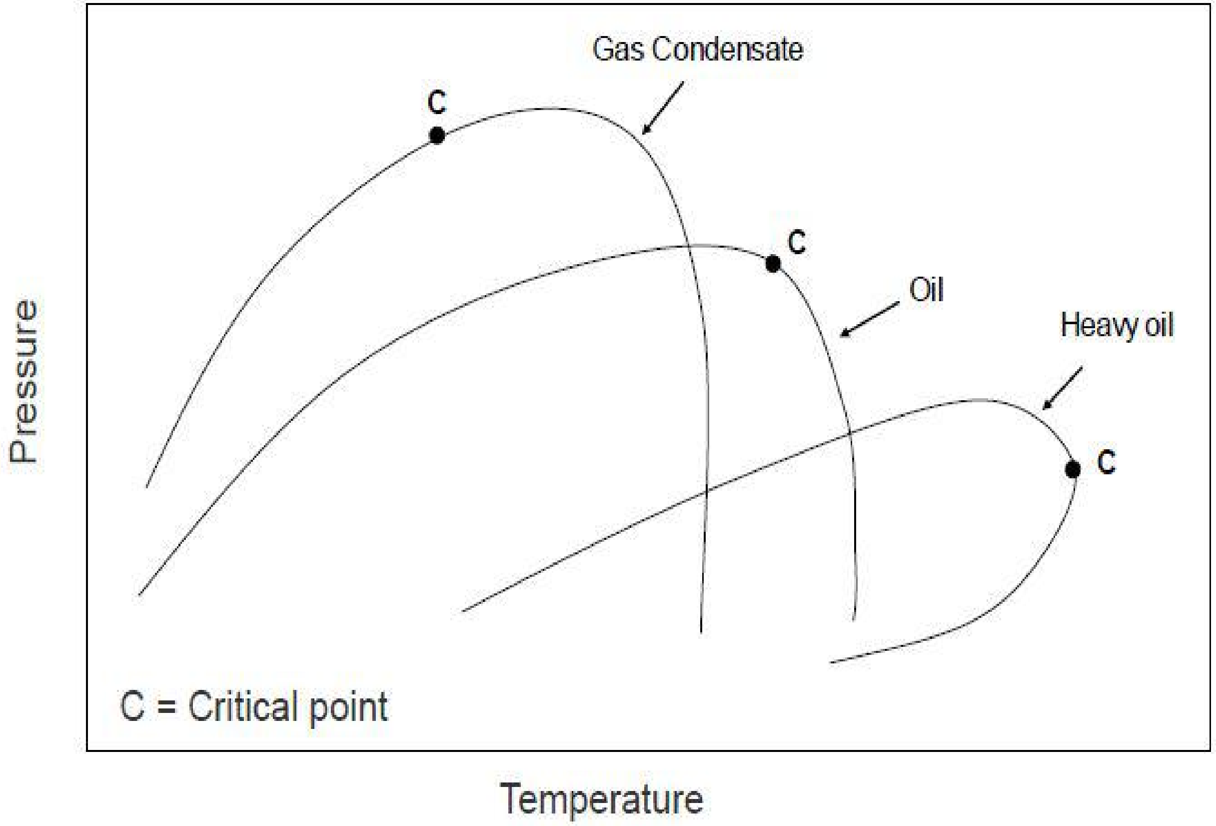
Examples

2. Oil



Examples

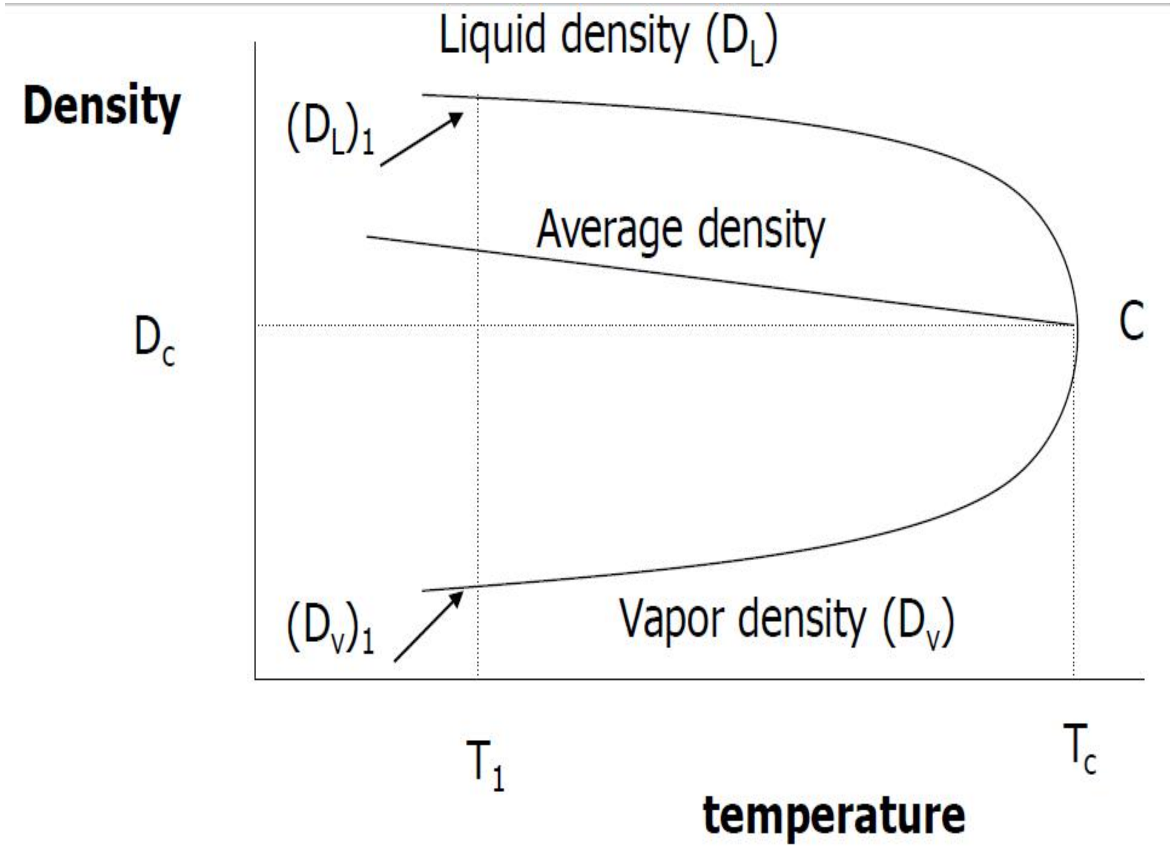
3. Three reservoir types



Density-Temperature diagram

Three cases

1. $\rho_{sys} > \rho_L$
2. $\rho_{sys} < \rho_v$
3. $\rho_L > \rho_{sys} > \rho_v$

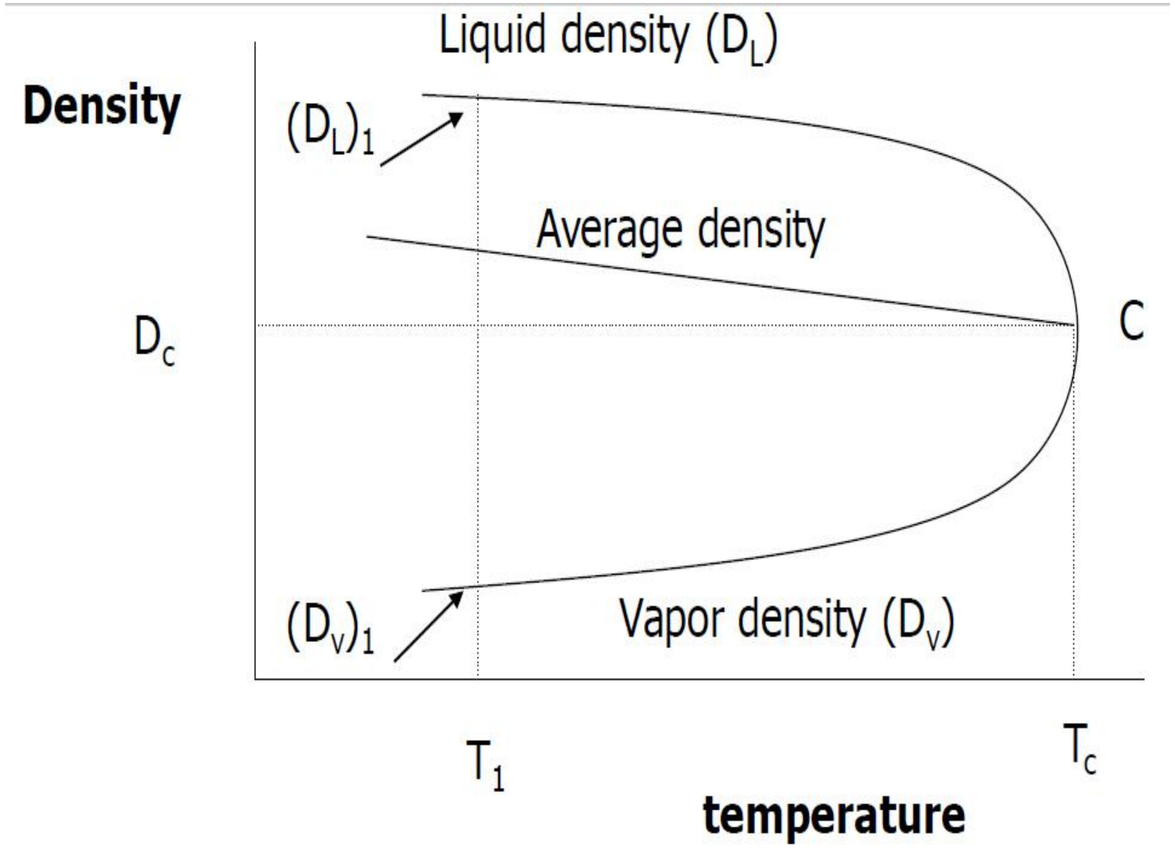


Density-Temperature diagram

Average density

$$\rho_{avg} = \frac{\rho_L + \rho_v}{2} = aT + b$$

$$V_c = \frac{MW}{\rho_C}$$



Density-Temperature diagram

Weight of liquid and vapor

$$V_L + V_v = V_T$$

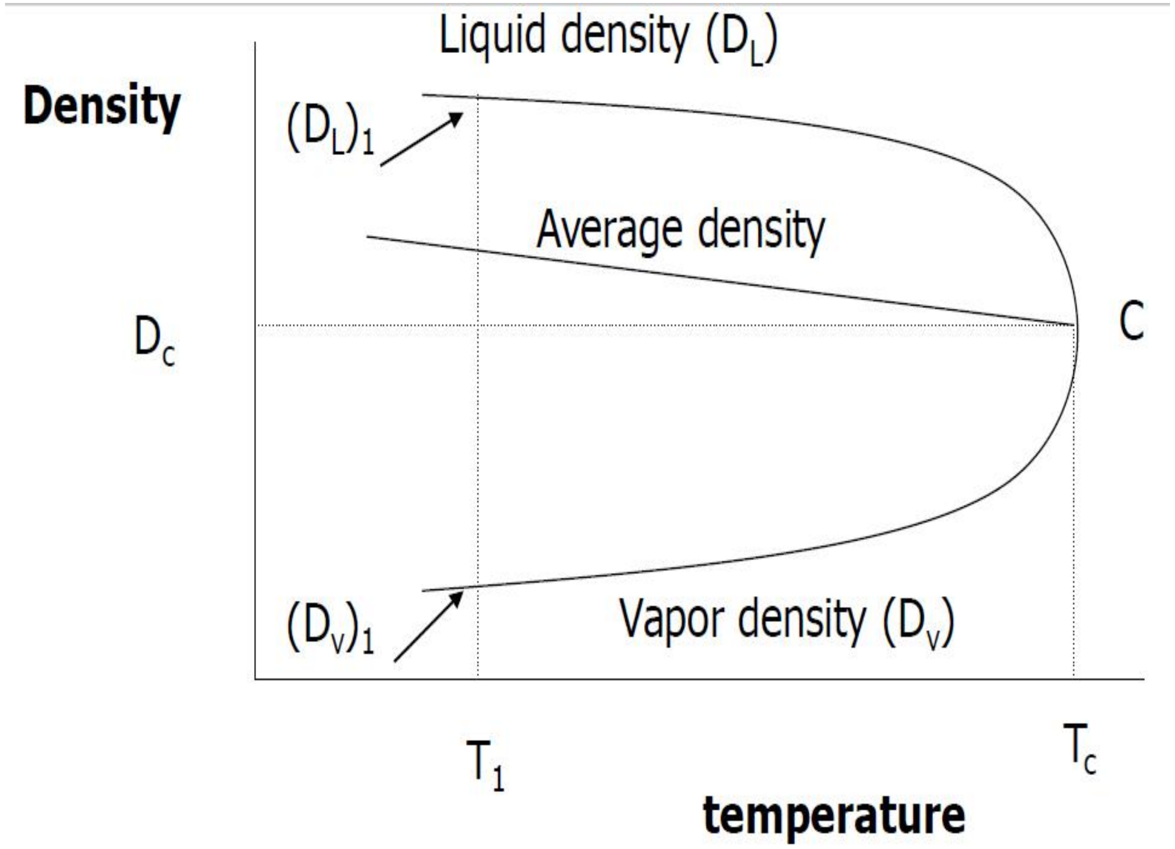
$$W_L + W_v = W_T$$

$$\rho_L = \frac{W_L}{V_L} \quad , \quad V_L = \frac{W_L}{\rho_L}$$

$$\rho_v = \frac{W_v}{V_v} \quad , \quad V_v = \frac{W_v}{\rho_v}$$

$$\frac{W_L}{\rho_L} + \frac{W_v}{\rho_v} = V_T$$

$$\frac{W_T - W_v}{\rho_L} + \frac{W_v}{\rho_v} = V_T$$



Density-Temperature diagram

Example

15 lb of HC is placed in 1 ft^3 vessel at 60 °F. The density of the coexisting liquid and vapor is 30 lb/ft^3 and 0.06 lb/ft^3 respectively.

Determine the weight and volume of the liquid and vapor phase.

Solution

$$\frac{15-W_v}{30} + \frac{W_v}{0.06} = 1$$

$W_v = 0.03$ lb , $W_L = 15 - 0.03 = 14.97$ lb

$$V_v = \frac{W_v}{\rho_v} = \frac{0.03}{0.06} = 0.5\ ft^3$$

$$V_L = 1 - V_v = 1 - 0.5 = 0.5\ ft^3$$