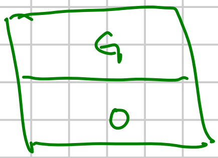
Note Title 5/11/2018

Two Phase Equilibrium

p, T



If in equilibrium

$\Rightarrow$ G is saturated at (p, T)

$$p = p_d(T)$$

$\Rightarrow$ O is saturated at (p, T)

$$p = p_b(T)$$

$$\text{Initial } m_o = \overset{\checkmark}{V_o} \cdot \overset{?}{\rho_{oi}} \Big/ \overset{?}{M_{oi}}$$

$\checkmark$

$HCPV_o$

$$M_o = \sum x_i M_i \Big/ \underbrace{\sum x_i}_{100}$$

$$\rho_o = \frac{\rho_o + \rho_g R_s}{B_o} \qquad \text{Table 6.7} \quad \rho_{ob}$$

Exam #4 PVT Data

use $\rho_{ob} = 1/\text{spec. volume}$

$$= \frac{m_{ob}}{V_{ob}} = \underset{@\,1270}{\rho_{ob}} \rightarrow \underset{@\,3015}{\rho_{oi}} = \frac{m_{oi}}{V_{oi}}$$

$$\rho_{oi} = \rho_{ob} \cdot \left(\frac{V_t}{V_{ob}}\right)^{-1}_{CCE}$$

$$\frac{m_o}{V_{ob}} \cdot \frac{V_{ob}}{\underset{@\,P_i}{V_t}}$$

$\boxed{\text{Theoretical AOFP}}$: ① $P_{wf} = 0$, ② $\Delta P_{tubing} = 0$: $P_{wf} = 0$

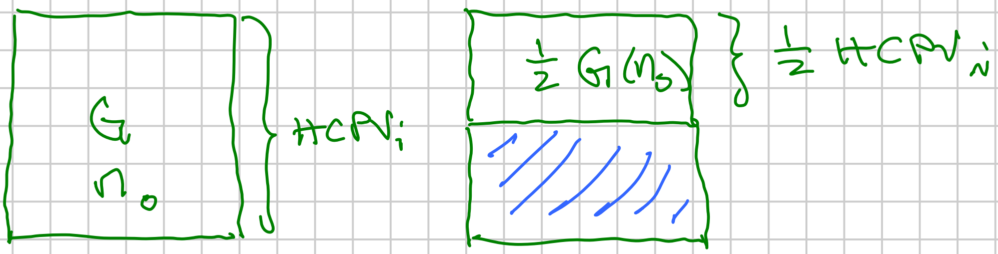
Wellhead Deliverability Curve

True AOFP : $q_g =$

$$B_{wH}\, q_g^2 + A_{wH}\, q_g - (P_c^2 - P_t^2) = 0$$

$$P_t = 0 \text{ or } P_{t\,min}$$

2013 : Prob. 1-3



P_{Ri} Z_{gi} $\qquad$ P_R ?

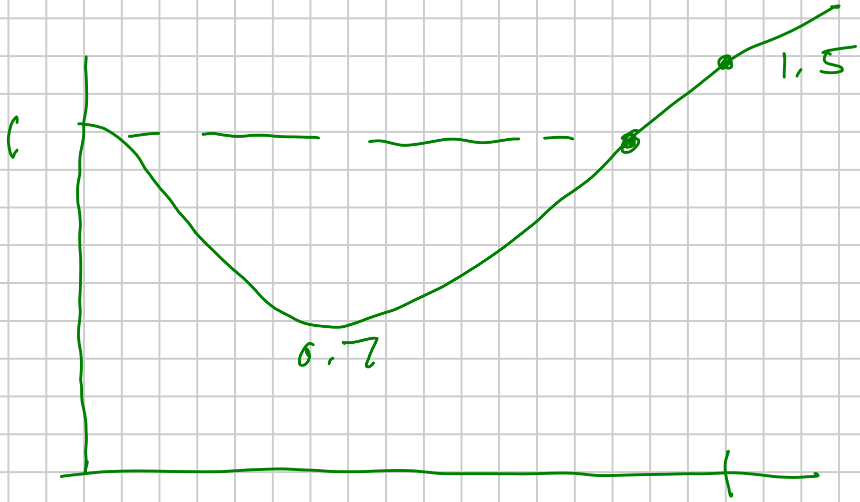
$$p_i V_i = n_i R T Z_i \qquad P_R \left(\tfrac{1}{2} V_i\right) = \tfrac{1}{2} n_i R T Z_g$$

$$\boxed{RT = \frac{p_i \cancel{V_i}}{\cancel{n_i} Z_i} = \frac{P_R\, \cancel{\tfrac{1}{2}} \cancel{V_i}}{\cancel{\tfrac{1}{2}} \cancel{n_i}\, Z}}$$

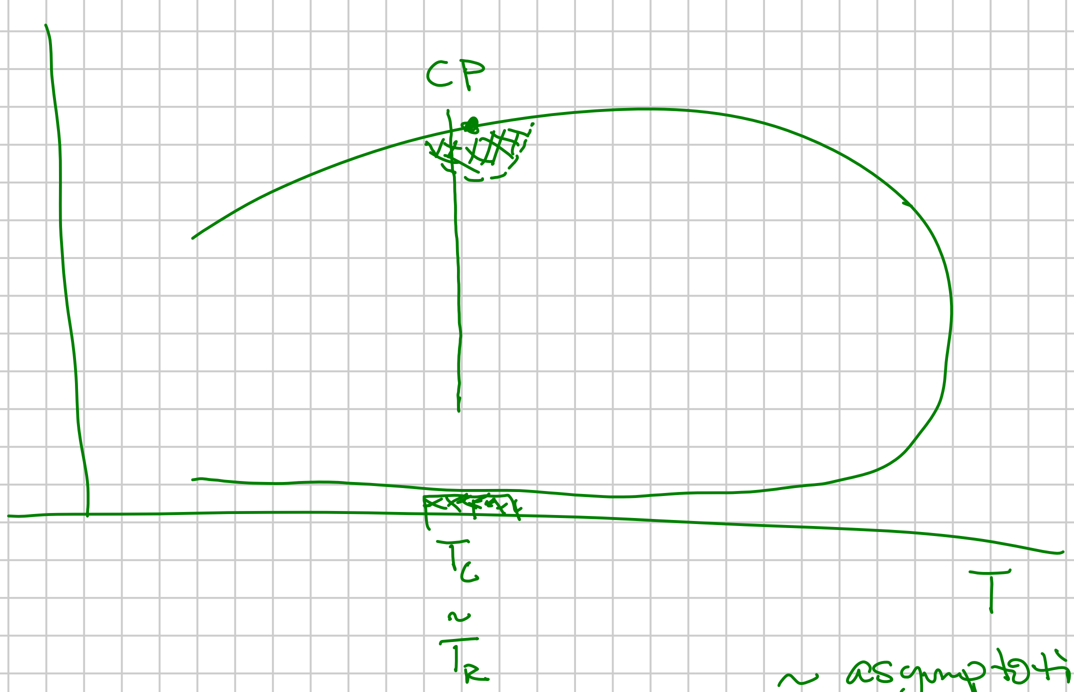
$$\boxed{\frac{P_i}{Z_i} = \frac{P_R}{Z_R}}$$

"Very Large Ag.

Infinite Size Ag.



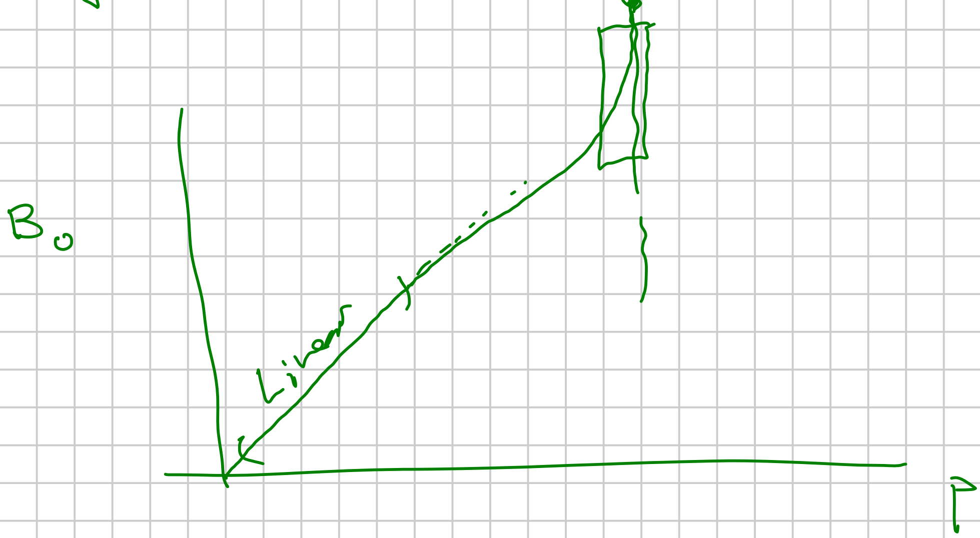
"Near Critical"



~ asymptotic
highly non-linear

(Two-Phase Properties) have "Large" changes with small pressure changes

$\rho \quad \mu \quad B \quad R_s \quad \gamma_s$



2016 ~ 2nd

$$\rho_g = \frac{P\, M_g}{R\, T\, Z_g}$$

Calc ✓

?

① ⇒ Back out Z_g

~~0.83~~ 0.935

② Calc M_g

⇒ T_{pc} P_{pc}

⇒ SK

~~0.~~ 0.88

2009 2h

R_t (V_g, V_o, r_{si}, R_{si})

$\underbrace{\text{Total GOR}}$

↓

$\boxed{(z_{C_{10}})_t}$

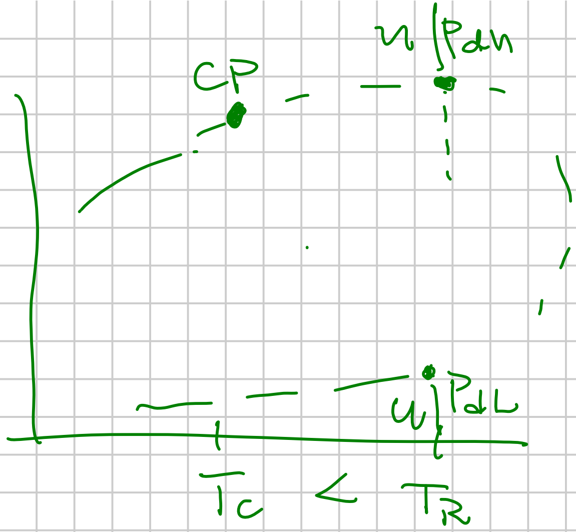
~

$z_{C_{7+}}$
C_{6+}
C_{5+}
S_{10}

$T_R > T_c$ $\quad$ P_d @ T_R $\quad$ RG : $z_{C_{10}}^{7+} \lesssim 15$ mol-%

$T_R < T_c$ $\quad$ P_b @ T_R $\quad$ RO : $\underbrace{\gtrsim 15 \text{ mol-\%}}$

RGC: $\boxed{(y_i) = (z_i)}$



$p > p_{du}$: Undersat. G.C.

$p < p_{dL}$ — " —

Gas MB w/ Aquifer

$\boxed{\text{IGIP } (G)}$: $\underbrace{\text{GC or Wet Gas}}_{B_{gdi}}$

When is correct to use:

(1) $\boxed{B_{gd}}$ vs "B_g" (2) $B_{gw} = \boxed{\frac{p_{sc}}{T_{sc}} \frac{T_R Z_g}{p}}$

$n_{gR} \neq n_{\bar{g}}$

$n_{gR} = n_{\bar{g}} + n_{\bar{o}}$

Gas Cond

Wet Gas

i.e. IF surface condensate is produced

Dry Gas

$n_{gR} = n_{\bar{g}}$

$n_{\bar{o}} = 0$

i.e. IF surface condensate is NOT produced

$$V_{ro} = \frac{V_o}{V_d} \quad @\, p \le p_d \qquad \text{from } \underline{\text{BOPVT}}$$

- $\rho_{\bar{o}}$
- $\rho_{\bar{g}}$

$B_o \quad B_{gd}$
$R_s \quad r_s$ $\Big\}$ (p)

Basis Initial $\underline{V_{\bar{o}g,i} = 1 \ Sm^3}$

$$V_o =$$

$$V_d = V_g \,@\, p_d = V_{\bar{g}g} \cdot B_{gd,d}$$

$$V_{\bar{g}g} = \frac{V_{\bar{o}g,i}}{r_{sd}}$$

$$\boxed{V_d = V_{\bar{o}g} \cdot \frac{1}{r_{sd}} \cdot B_{gd,d}} = \frac{B_{gd,d}}{r_{sd}}$$

$$V_o = V_{\bar{o}o} \cdot B_o = \left(1 - \left(\frac{1}{r_{si}} - \frac{R_s}{B_o} V_o\right) r_s\right)$$

$$\Rightarrow V_o$$

$$V_{\bar{o}o} = \overset{=1}{V_{\bar{o}g,i}} - V_{\bar{o}g}$$

initial remaining

surface oil in gas

$$V_{\bar{o}g} = \underbrace{V_g / B_{gd}}_{V_{\bar{g}g}} \cdot r_s$$

$$V_{\bar{o}g} = V_{\bar{g}g} \cdot r_s = \left(\frac{1}{r_{si}} - \frac{R_s}{B_o} V_o\right) r_s$$

$$V_{\bar{g}g} = V_{\bar{g}g,i} - V_{\bar{g}o} \qquad \text{M. B.}$$

$$= \frac{\overset{=1}{V_{\bar{o}g,i}}}{r_{si}} - \underbrace{(V_o / B_o)}_{V_{\bar{o}o}} R_s$$

$$= \frac{1}{r_{si}} - V_o \left(R_s / B_o\right)$$

$$V_o = V_{\bar{o}o} \cdot \overset{\checkmark}{B_o} = \left(1 - \left(\frac{1}{r_{si}} - \frac{R_s}{B_o} V_o\right) r_s\right)$$

$$\Rightarrow V_o$$

$$V_o = 1 - \frac{r_s}{r_{si}} + \frac{R_s}{B_o} r_s V_o$$

$$V_o \left(1 - \frac{R_s}{B_o} r_s\right) = 1 - \frac{r_s}{r_{si}}$$

$$V_o = \frac{1 - r_s / r_{si}}{1 - \frac{R_s}{B_o} r_s}$$

$$V_{ro} = \frac{V_o}{V_d} = \left[\frac{1 - r_s / r_{si}}{1 - \frac{R_s}{B_o} r_s} \right] \cdot \underbrace{r_{si}}_{\frac{B_{gd,d}}{\cancel{r_{si}}}}$$

$$\boxed{V_{ro} \quad \frac{(r_{si} - r_s)}{\left(1 - \frac{R_s}{B_s} r_s\right) B_{gd,d}}}$$

Mat. Bal. on $V_{\bar{g}}$ $V_{\bar{o}}$

$$V_{\bar{g}} = V_{\bar{g}g} + V_{\bar{g}o}$$

$$V_{\bar{o}} = V_{\bar{o}g} + V_{\bar{o}o}$$