# RECOVERY (FACTOR) CALCULATIONS

Note Title 1/11/2018

## Class Problem Discussion:

Estimate Recovery Factor for four situations, where initial condition is 100 bar in a container and final condition, after "production" removal of something from the container, is 1 bar.

| | | Initial Phase @ 100 bar |
|---|---|---|
| ① | Pure $H_2O$ | Liquid |
| ② | Pure $CO_2$ | Gas |
| ③ | $H_2O$ saturated with $CO_2$ | Liquid |
| ④ | $CO_2$ saturated with $H_2O$ | Gas |

# RECOVERY (FACTOR) CALCULATIONS

$$RF_x = \frac{Q_p}{Q_{Ri}} = \frac{N_p}{N} = \frac{G_p}{G}$$

$RF_{\bar{o}}$    $RF_{\bar{g}}$

$x$ = surface product

$\bar{g}$ SG

$\bar{o}$ SO (STO)

$Q$ = Total cumulative volume

$N$ = IOIP ISTOIP OOIP

$G$ = IGIP OGIP

$Q_{Ri}$ = ficticous surface product volume produced IF all of the reservoir fluids at $P_{Ri}$ were brought to the surface and recovered at the surface

$Q_P = Q_{Ri} - Q_R$ = actual surface product volume produced @ $P_R$

$Q_R$ = ficticous surface product volume produced IF all of the reservoir fluids at $P_R$ were brought to the surface and recovered at the surface

(1) Reservoir Pore Volume $V_p(p_R)$ $V_p(p)$

(2) Reservoir Fluids Volume $V_f(p)$
- $V_g(p)$
- $V_o(p)$
- $V_w(p)$

- of the reservoir fluids in the pores currently

(3) What reservoir fluids stay in the pore volume
- $V_{pg}(p)$
- $V_{po}(p)$
- $V_{pw}(p)$

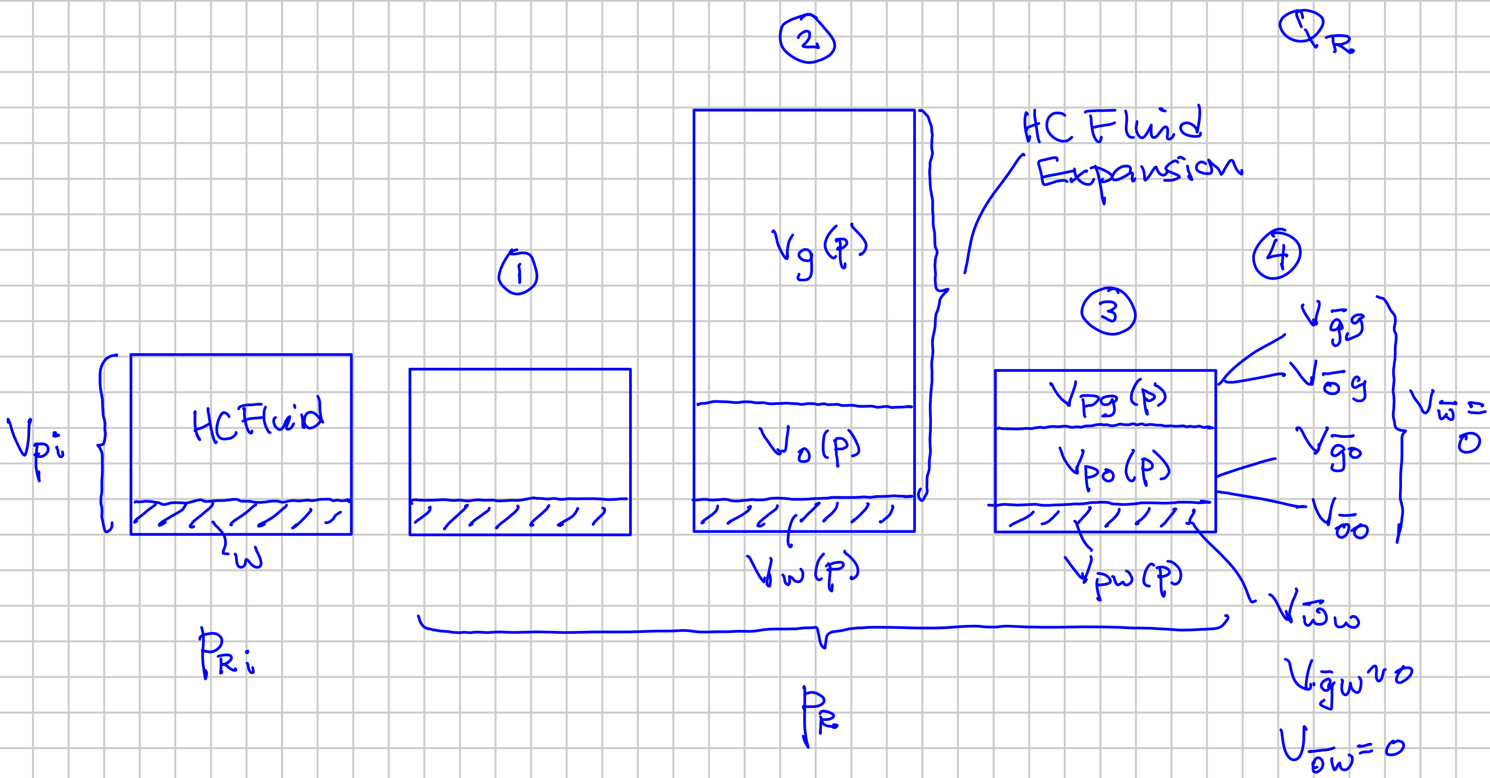
- $k_r(S)$
- Darcy
- Geology
- Well locations
- Injectors
- Aquifer

"R" Oils - very complicated (another course)
"R" Gases - simpler & in this course

(4) Convert reservoir phase volumes into surface product volumes $f(p)$

$B$ — Volume Factor

$R_s$ $r_s$ — Solution Gas-Oil, Oil ... Ratios




(2) Reservoir Fluid (Gas & Oil) Volumetric & Phase Behavior

Given: $n_F$ $z_{Rj}$

$n_F$ = Total HC Fluid Moles currently in the R

$z_{Rj}$ = Mole fraction of Fluid component $j$

Calculate: (Thermodynamics – EOS)

- # Phases
- Phase Amounts $n_g$ $n_o$, $m_g$ $m_o$, $V_g$ $V_o$
- Phase Compositions $y_j$ $x_j$

$$y_j = \frac{n_{jg}}{n_g} \qquad x_j = \frac{n_{jo}}{n_o}$$

Gas Phase  Oil Phase

- Phase Properties $\rho_g$ $\rho_o$

$M_g$ $M_o$

Equations of State: Eq. p-V-T-n

Cubic EOS

- van der Waals 185x?
- Redlich-Kwong (Soave) SRK ✓
- Peng-Robinson PR ✓

Apply to Gas (vapor) and Liquid (oil) Phases

Near-Critical phase behavior

Used Reservoir - Production - Surface Process

Pure $H_2O$: $c = -\frac{1}{V}\left(\frac{dV}{dp}\right)_{T,n} = \text{constant}$

Pure $CO_2$: $pV \cong nRT$

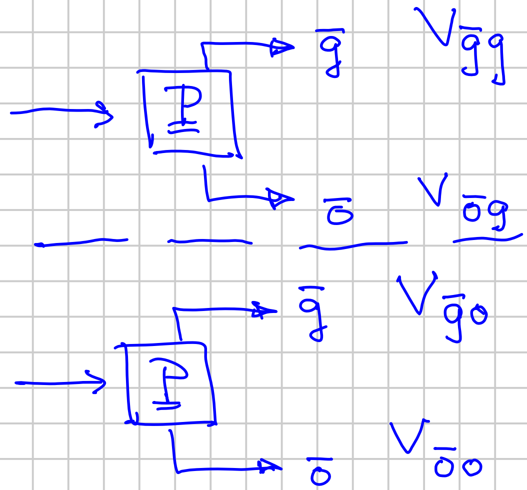
④ @ $p$

R Gas Phase

$n_g(p)$, $V_g(p)$, $y_i(p)$

R Oil Phase

$n_o(p)$, $V_o(p)$, $x_i(p)$




$$r_s(p) = \frac{V_{\bar{o}g}(p)}{V_{\bar{g}g}(p)}$$

$$B_g(p) = \frac{V_g(p)}{V_{\bar{g}g}(p)}$$

$$R_s(p) \equiv \frac{V_{\bar{g}o}(p)}{V_{\bar{o}o}(p)}$$

$$B_o(p) = \frac{V_o(p)}{V_{\bar{o}o}(p)}$$

"EOS"
(Lab Data)

Footnote: Surface volume conservation is only an approximation

0.2% error ⇒ < 3% error

$(N_p)_{correct}$ vs $(N_p)_{approx.}$