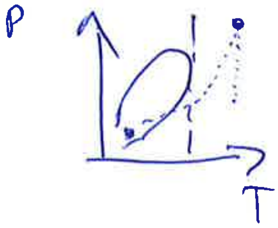
300117

WET GAS MATERIAL BALANCE



1 bbl STO - stock tank oil, GE - gas equivalent

$$GE_{STO} = n \cdot \frac{10.732 \cdot (60+460)}{14.7}$$

must find number of lb mol in 1 bbl STO

$$n_{STO} = 350.54 \cdot \frac{\gamma_{STO}}{M_{STO}} \qquad \text{(lb mol)}$$

Inserted into GE_{STO}

$$GE_{STO} = V_{sc} = \frac{\gamma_{STO}}{M_{STO}} \cdot 350.54 \cdot \frac{10.732 \cdot 520}{14.7}$$

For 1 bbl STO:

$$GE_{STO} \approx 133\,000 \frac{\gamma_{STO}}{M_{STO}} \quad \frac{SCF}{SBL}$$

Field units

$$1\ Sm^3 \text{ olje} \quad GE_{STO} \approx \frac{133000}{5.615} \frac{\gamma_{STO}}{M_{STO}} \approx 23696 \frac{\gamma_{STO}}{M_{STO}} \frac{Sm^3_g}{Sm^3_o}$$

$$\text{Total } GE_{STO}\ (SCF) = GE_{STO}\left(\frac{SCF}{1\ SBL}\right) \cdot V_{STO}\ (SBL)$$

If only γ_{STO} is given:

Cragoes formula to find M_{STO}:

$$M_{STO} = \frac{6084}{°API - 5.9} \qquad °API = \frac{141.5}{\gamma_o} - 131.5$$

Gas equivalent volume of produced water:

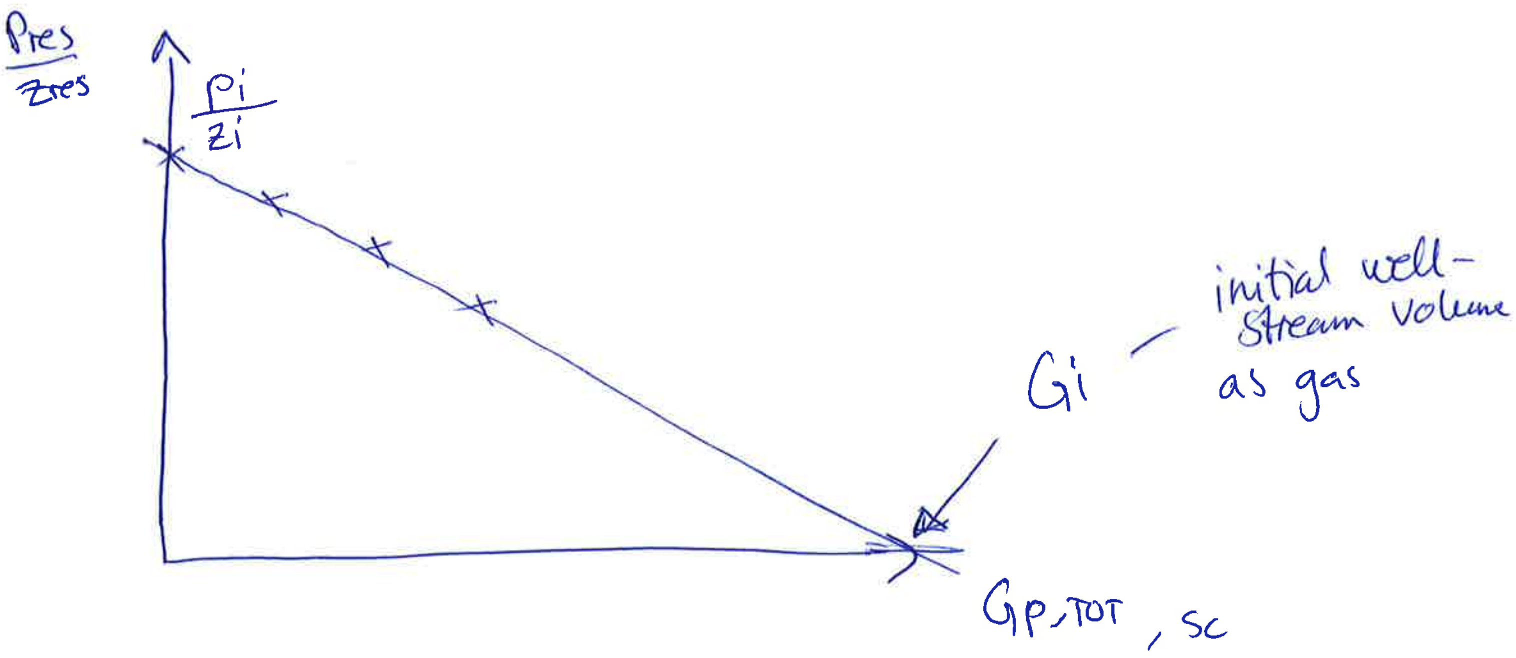
$\gamma_w = 1 \qquad M_w = 18$

$$1 \text{ bbl} \qquad GE_w \approx 133\,000 \cdot \frac{1}{18} = 7389 \, \frac{SCF}{SBL}$$

Wellstream as gas produced:

$$G_{p,sc} = V_{g,sc} + V_{STO} \cdot GE_{STO} + (V_w \cdot GE_w)_{sc} + (V_{wvp} \cdot GE_{wvp})_{sc}$$

$G_{p,TOT}$ — produced gas — produced oil in gas equivalents — prod. fresh water



IGIP and IOIP

IGIP – initial gas in place

IOIP – initial oil in place

To determine IGIP and IOIP

⇒ we need to know the mol fractions of the reservoir fluid

V (gas) – molfraction gas

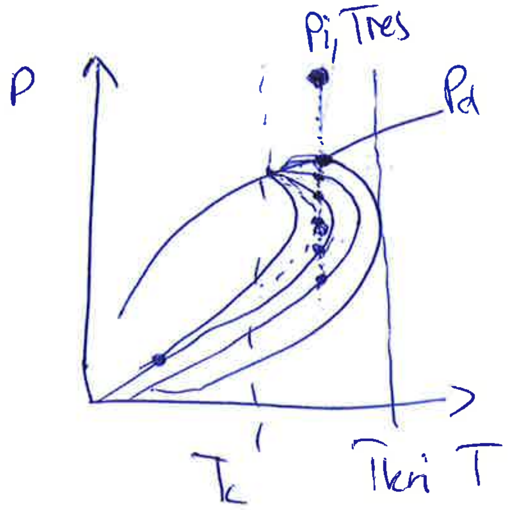
L (liquid) – mol fraction liquid.

V and L can be determined in a flash process in the lab.

$$G_i = IGIP + IOIP \cdot GE_{STO}$$

$$GOR_{initially} = \frac{IGIP}{IOIP} \qquad \frac{SCF}{SBL}$$

GAS CONDENSATES



$T_c < T_{res} < T_{kri}$
sc inside two-phase envelope

Retrograde condensation
- liquid is condensing at lower P, liquid volume is increasing to a maximum, then evaporates again.

Calculation of oil and gas production:

Material balance ~~equation~~ calculations are depending on Pres !: higher than Pd
lower than Pd

1. Pres > Pd : Mat. bal. as for wet gas
   Convert produced STO (and water) into gas equivalents.

2. Pres < Pd : PVT-analysis to be performed in the lab.
   Production of oil and gas based on CVD-analysis data.
   "constant volume depletion"
   "konstant volumavlastnings-analyse".

Pres < Pd : large amounts of liquid condensing in the reservoir, This is usually lost. => Productivity is reduced.

Gas production is impaired by near-well blockage of condensed oil.

CVD - analysis

PVT - cell : oil and gas from separator are recombined to represent the reservoir fluid, → added to the PVT - cell.

Pd - dew point pressure
Tres - reservoir temperature

Note volume of cell at these conditions.

Cell volume is increased by ΔV_1, pressure drops to P_1. After new equilibrium between oil and gas has been established, a volume ΔV_1 of gas is produced. Pressure still at P_1.

Retrograde liquid volume
Compositions of produced gas and oil } determined
z - factor for gas

Procedure is repeated approx. 10 times until abandonment pressure has been reached.

Simulating pressure depletion of a reservoir.

* Calculate produced well stream as gas at sc, $\Delta G_{p,sc}$:

The ratio between produced gas and reservoir gas volume is equal to the ratio produced gas from the PVT-cell and the volume of the PVT-cell

- Valid when P and T conditions are the same in reservoir and cell.
  Also at standard conditions, sc.

For a pressure interval i :

$$\frac{(\Delta G_p)_i}{V_{HCPV}} = \frac{(\Delta V_g)_i}{V_{cell}} \Rightarrow (\Delta G_p)_i = V_{HCPV} \cdot \frac{(\Delta V_g)_i}{V_{cell}}$$

$(\Delta G_p)_i$ = produced well stream fluid as gas in pressure interval i

$(\Delta V_g)_i$ = produced gas volume from the cell in pressure interval i

V_{cell} = volume of gass initially in PVT-cell

V_{HCPV} = hydrocarbon pore volume

⇒ All these volumes are given at sc — standard conditions)

$V_{HCPV,sc}$, $(\Delta V_g)_{i,sc}$, $V_{cells,sc}$ } can be determined by finding the number of moles in the actual volume, by $pV = ZnRT$

$\Rightarrow n = \frac{pV}{ZRT}$,

then multiplying with V_m – molar volume

volume of 1 mol gas at standard conditions.

$$V_{HCPV,sc} = \underbrace{\frac{P_d \cdot V_{HCPV,res}}{Z_d \cdot R \cdot T_{res}}}_{n} \cdot V_m \qquad (n \cdot V_m)$$

$$(\Delta V_g)_{i,sc} = \frac{P_i \cdot (\Delta V_g)_{i,res}}{Z_i \cdot R \cdot T_{res}} \cdot V_m$$

d = dew point

res = reservoir

i = pressure interval.

$$V_{cells,sc} = \frac{P_d \cdot V_{cell,res}}{Z_d \cdot R \cdot T_{res}} \cdot V_m$$

Use these three expressions to determine produced wellstream as gas, $(\Delta G_p)_{i,sc}$, in the pressure interval i.

* How much gas and oil is produced?

GOR for each pressure step.

$$GOR = \frac{(\Delta V_g)_{i,sc}}{(\Delta V_o)_{i,sc}}$$ volume separator gas / volume STO

* Produced separator gas volume at sc $(\Delta V_g)_i$

For pressure interval i:
Volume of separator gas is found by subtracting the part of the well stream that becomes oil, from the total wellstream as gas. Heavier components, a fraction of these, will be part of the oil phase.

$$(\Delta V_g)_{i,sc} = (\Delta G_p)_{i,sc} - (\Delta G_L)_{i,sc}$$

$(\Delta G_L)_{i,sc}$: Well stream volume that becomes liquid. (gas volume, SCF)

How to determine the part of the wellstream that becomes liquid.

$$(\Delta G_L)_{i,sc} = (\Delta n_L)_i \, (\Delta G_p)_{i,sc}$$

$(\Delta n_L)_i$ = liquid mol fraction, the fraction that becomes liquid.

$(\Delta n_L)_i$ is found by multiplying the mol fractions (z_i) for each liquid component (C_4, C_5, C_6, C_{7+}) with liquid recovery factors for the well stream (a, b, c, d)

↳ fraction of the component in liquid phase.

$$(\Delta n_L)_i = a \cdot (z_{C_4})_i + b(z_{C_5})_i + c(z_{C_6})_i + d(z_{C_{7+}})_i$$

⊕ Produced liquid volume, $(\Delta V_o)_{i,sc}$

~~Calc~~ Calculate the liquid volume, V_L, for every component, then add them together.