

PARAMETERS AND CORRELATIONS

1. PVT OIL

1.1 Bubble Point Pressure

1) Standing Correlation

$$p_b = 18.2 [(R_s/\gamma_g)^{0.83} (10)^a - 1.4]$$

with

$$a = 0.00091 (T - 460) - 0.0125 (\text{API})$$

where p_b = bubble-point pressure, psia
 T = system temperature, °R

2) Vasquez-Beggs

$$p_b = [(C_1 R_s / \gamma_{gs}) (10)^a]^{C_2}$$

with

$$a = -C_3 \text{API}/T$$

Coefficient	API < 30	API > 30
C ₁	27.624	56.18
C ₂	0.914328	0.84246
C ₃	11.172	10.393

1.2 Gas Oil Ratio (Rs)

1) Standing Correlation

$$R_s = \gamma_g \left[\left(\frac{p}{18.2} + 1.4 \right) 10^x \right]^{1.2048}$$

$$x = 0.0125 \text{API} - 0.00091(T - 460)$$

where T = temperature, °R
 p = system pressure, psia
 γ_g = solution gas specific gravity

2) Vasquez-Beggs

$$R_s = C_1 \gamma_{gs} p^{C_2} \exp \left[C_3 \left(\frac{\text{API}}{T} \right) \right]$$

Values for the coefficients are as follows:

Coefficient	API < 30	API > 30
C ₁	0.0362	0.0178
C ₂	1.0937	1.1870
C ₃	25.7240	23.931

$$\gamma_{gs} = \gamma_g \left[1 + 5.912 (10^{-5}) (\text{API}) (T_{\text{sep}} - 460) \log \left(\frac{p_{\text{sep}}}{114.7} \right) \right]$$

where γ_{gs} = gas gravity at the reference separator pressure
 γ_g = gas gravity at the actual separator conditions of p_{sep} and T_{sep}
 p_{sep} = actual separator pressure, psia
 T_{sep} = actual separator temperature, °R

1.3 Formation Volume Factor of Oil (Bo)

- a. *Saturated* : *Standing's Correlation*

$$\beta_o = 0.9759 + 0.000120 \left[R_s \left(\frac{\gamma_g}{\gamma_o} \right)^{0.5} + 1.25(T - 460) \right]^{1.2}$$

- b. *Undersaturated* : *Vasquez-Beggs Correlation*

$$B_o = 1.0 + C_1 R_s + (T - 520) \left(\frac{API}{\gamma_{gs}} \right) [C_2 + C_3 R_s]$$

Coefficient	API " 30	API > 30
C ₁	4.677×10^{-4}	4.670×10^{-4}
C ₂	1.751×10^{-5}	1.100×10^{-5}
C ₃	-1.811×10^{-8}	1.337×10^{-9}

1.4 Oil Viscosity (μ_o)

- a. *Saturated* : *Beggs-Robinson's Correlation*

Can be calculated after getting dead oil viscosity through Beggs-Robinson's Correaltion

$$\mu_{ob} = a(\mu_{od})^b$$

$$\text{where } a = 10.715(R_s + 100)^{-0.515}$$

$$b = 5.44(R_s + 150)^{-0.338}$$

- b. *Undersaturated* : *Vasquez-Beggs' Correlation*

Can be calculated after getting saturated oil viscosity through Beggs-Robinson's Correaltion

$$\mu_o = \mu_{ob} \left(\frac{p}{p_b} \right)^m \quad \begin{aligned} m &= 2.6 p^{1.187} 10^a \\ a &= -3.9(10^{-5}) p - 5 \end{aligned}$$

1.5 Oil Density

Standard method

$$\rho_o = \frac{62.4 \gamma_o + 0.0136 R_s \gamma_g}{B_o}$$

where γ_o = specific gravity of the stock-tank oil

R_s = gas solubility, scf/STB

ρ_o = oil density, lb/ft³

1.6 Oil Isothermal Compressibility (Co)

- a. Saturated : Correlation B-51 in McCain

$$c_o = 10^{-6} e^{\left[\frac{p_{ob} + 4.347 \times 10^{-3}(p - p_b) - 79.1}{7.141 \times 10^{-4}(p - p_b) - 12.938} \right]}$$

- b. Undersaturated : Vasquez-Begg's correlation

$$c_o = \frac{-1,433 + 5R_{sb} + 17.2(T - 460) - 1,180 \gamma_{gs} + 12.61^\circ \text{ API}}{10^5 p}$$

where T = temperature, °R
p = pressure above the bubble-point pressure, psia
R_{sb} = gas solubility at the bubble-point pressure

2. PVT GAS

2.1 Critical Properties (P_{pc}, T_{pc}, P'_{pc}, and T'_{pc})

Data of hydrocarbon's specific gravity needed.

Kay's Mixture Rule Pseudocritical Pressure and Pseudocritical Temperature Correlation and Correction

- a. Natural Gas Pseudocritical Pressure and Pseudocritical Temperature

1) Standing's Correlation

Case 1: Natural Gas Systems

$$T_{pc} = 168 + 325 \gamma_g - 12.5 \gamma_g^2$$

$$p_{pc} = 677 + 15.0 \gamma_g - 37.5 \gamma_g^2$$

Case 2: Gas-Condensate Systems

$$T_{pc} = 187 + 330 \gamma_g - 71.5 \gamma_g^2$$

2) Sutton's Correlation

$$p_{pc} = 756.8 - 131.07 \gamma_g - 3.6 \gamma_g^2$$

$$T_{pc} = 169.2 + 349.5 \gamma_g - 74.0 \gamma_g^2$$

- b. Gas Condensate Pseudocritical Pressure and Pseudocritical Temperature

Carr-Kobayashi-burrows method, pseudocritical pressure correction, pseudocritical temperature correction

2.2 Pseudoreduce Pressure (Ppr) and Pseudoreduce Temperature (Tpr)

We can find PPr by divide P over the Ppc, also the Tpr by dividing T over Tpc.

$$P_{pc} = \frac{P}{P_c}$$

$$T_{pc} = \frac{T}{P_c}$$

$$T'_{pc} = T_{pc} - 80 y_{CO_2} + 130 y_{H_2S} - 250 y_{N_2}$$

$$P'_{pc} = P_{pc} + 440 y_{CO_2} + 600 y_{H_2S} - 170 y_{N_2}$$

2.3 Z-Factor Calculation

Hall-Yarborough's Method

$$z = \left[\frac{0.06125 p_{pr} t}{Y} \right] \exp [-1.2(1-t)^2] \quad (2-36)$$

where p_{pr} = pseudo-reduced pressure

t = reciprocal of the pseudo-reduced temperature, i.e., T_{pc}/T

Y = the reduced density that can be obtained as the solution of the following equation:

$$F(Y) = X1 + \frac{Y + Y^2 + Y^3 + Y^4}{(1-Y)^3} - (X2) Y^2 + (X3) Y^{X4} = 0$$

where $X1 = -0.06125 p_{pr} t \exp [-1.2 (1-t)^2]$

$X2 = (14.76 t - 9.76 t^2 + 4.58 t^3)$

$X3 = (90.7 t - 242.2 t^2 + 42.4 t^3)$

$X4 = (2.18 + 2.82 t)$

2.4 Gas Isothermal Compressibility (Cg)

Dranchuk-Purvis-Robinson's Method

$$1 + T_1 \rho_r + T_2 \rho_r^2 + T_3 \rho_r^5 + [T_4 \rho_r^2 (1 + A_8 \rho_r^2) \exp(-A_8 \rho_r^2)] - \frac{T_5}{\rho_r} = 0$$

$$T_1 = \left[A_1 + \frac{A_2}{T_{pr}} + \frac{A_3}{T_{pr}^3} \right]$$

$$T_2 = \left[A_4 + \frac{A_5}{T_{pr}} \right]$$

$$T_3 = [A_5 A_6 / T_{pr}]$$

$$T_4 = [A_7 / T_{pr}^3]$$

$$T_5 = [0.27 p_{pr} / T_{pr}]$$

$$A_1 = 0.31506237$$

$$A_2 = -1.0467099$$

$$A_3 = -0.57832720$$

$$A_4 = 0.53530771$$

$$A_5 = -0.61232032$$

$$A_6 = -0.10488813$$

$$A_7 = 0.68157001$$

$$A_8 = 0.68446549$$

2.5 Formation Volume Factor (FVF) of gas (Bg)

Real Gas EOS Ratio

Since in this book $T_{sc} = 520^\circ R$, $p_{sc} = 14.65$ psia, and for all practical purposes $z_{sc} = 1$, then

$$B_g = \frac{zT(14.65)}{(1.0)(520)p} = 0.0282 \frac{zT}{p} \frac{\text{cu ft}}{\text{scf}}. \quad (6-2)$$

Also,

$$B_g = \left(0.0282 \frac{zT}{p} \frac{\text{cu ft}}{\text{scf}} \right) \left(\frac{\text{bbl}}{5.615 \text{ cu ft}} \right) = 0.00502 \frac{zT}{p} \frac{\text{res bbl}}{\text{scf}}, \quad (6-3)$$

2.6 Density Of Gas

Gas Equation of State Modification

$$R = 10.732$$

$$MW_{\text{AIR}} = 28.965$$

$$\text{Density of Gas} = SG * \text{Air Molar Weight} * p / (Z * R * (T + 460))$$

2.7 Viscosity of gas (μ_g)

Lee-Gonzalez-Eaking Method

$$\mu_g = 10^{-4} K \exp \left[X \left(\frac{\rho_g}{62.4} \right)^Y \right]$$

where

$$K = \frac{(9.4 + 0.02 M_a) T^{1.5}}{209 + 19 M_a + T}$$

$$X = 3.5 + \frac{986}{T} + 0.01 M_a$$

$$Y = 2.4 - 0.2 X$$

ρ_g = gas density at reservoir pressure and temperature, lb/ft³

T = reservoir temperature, °R

M_a = apparent molecular weight of the gas mixture

3. PVT Formation Water

3.1 Water Formation Volume Factor (B_w)

McCain

$$B_w = (1 + \Delta V_{wp})(1 + \Delta V_{wT}),$$

$$\Delta V_{wp} = -1.0001 \times 10^{-2} + 1.33391 \times 10^{-4} T + 5.50654 \times 10^{-7} T^2,$$

$$\Delta V_{wT} = -1.95301 \times 10^{-9} p T - 1.72834 \times 10^{-13} p^2 T$$

$$-3.58922 \times 10^{-7} p - 2.25341 \times 10^{-10} p^2,$$

3.2 Water Viscosity (μ_w)

1) Standard Method

$$\mu_w = \mu_{wD} [1 + 3.5 \times 10^{-2} p^2 (T - 40)]$$

$$\mu_{wD} = A + B/T$$

$$A = 4.518 \times 10^{-2} + 9.313 \times 10^{-7} Y - 3.93 \times 10^{-12} Y^2$$

$$B = 70.634 + 9.576 \times 10^{-10} Y^2$$

μ_w = brine viscosity at p and T, cp

μ_{wD} = brine viscosity at p = 14.7, T, cp

p = pressure of interest, psia

T = temperature of interest, T °F

Y = water salinity, ppm

2) Beggs & Brill (1978)

Beggs & Brill (1978)

$$\mu_w = \exp (1.003 - 1.479 \times 10^{-2} T + 1.982 \times 10^{-5} T^2)$$

3.3 Density of Brine

McCain

$$\rho_w = 62.368 + 0.438603 \times S + 1.60074 \times 10^{-3} \times S^2, \dots \dots \dots (1)$$

where density is in lbm/ft³, and S is salinity in weight percent. Then, density at reservoir conditions is calculated by dividing the density in Eq. 1 by the brine FVF at the reservoir temperature and pressure of interest.

3.4 Solubility of Methane in Pure Water (Rsw)

McCain

3.5 Water Isothermal Compressibility

$$C_w = (C_1 + C_2 T + C_3 T^2) \times 10^{-6}$$

$$C_1 = 3.8546 - 0.000134 p$$

$$C_2 = -0.01052 + 4.77 \times 10^{-7} p$$

$$C_3 = 3.9267 \times 10^{-5} - 8.8 \times 10^{-10} p$$

T = °F

p = psia

$C_w = \text{psi}^{-1}$

FEATURES ON SPREADSHEET

1. There are 5 sheets on our excel, which are:
 - a. **Sign In** : Sheets where we input the oil field and the engineer
 - b. **Main** : Sheet where we input the known data, and choose which correlation we want to use.
 - c. **PVT Calculator** : Sheet that show the result of our calculation
 - d. **Table** : Sheet that show the table of pressure for 36 pressures from initial reservoir pressure which is input value until pressure at standard condition
 - e. **Grafik** : Sheet that show the graph of the properties

2. This excel can calculate the properties of oil, gas, and formation water.
3. The data of oil, gas, and separator can be input by user.
4. There is table that show all the result of properties calculation for different pressure.
5. We can see the graphs of each properties.
6. We can sign in to the excel
7. We can see the identity of creators by click “ABOUT” button on main sheet

PVT ANALYSIS

FLUID PROPERTIES IN OIL RESERVOIR

Field :

Engineer :

[SIGN IN](#)

SIGN IN SHEET

OIL RESERVOIRS

FLUID PROPERTIES CORRELATION

GENERAL DATA	
Reservoir Pressure	= 2500 psia
Standard Pressure	= 14.6 psia
Reservoir Temperature	= 200 °F
SG gas	= 0.87

OIL DATA	
Separator Pressure	= 150 psia
Separator Temperature	= 60 °F
Oil API	= 60 °API
Rs at Pb	= 2000 scf/STB
Select Correlation	2

IMPURITIES (% MOL)	
CO ₂	= 0.25 %
H ₂ S	= 0.25 %
N ₂	= 0 %

CRITICAL GAS DATA	
Correlation :	2 Ppc = 652.6 psia
	Tpc = 420 °R
Correction :	1 P'pc = 655.2 psia
	T'pc = 420.1 °R

PSEUDOREduced PROPERTIES	
Ppr	= 6.86792841
Tpr	= 1.57102964

WATER DATA	
Water Salinity	= 50000 ppm
Select Correlation (μw)	2

SYSTEM DATA	
System Pressure	= 4500 psia

FIELD : Duri

ENGINEER : Putra Arcana

PVT CHARTS

PVT CALCULATOR

PVT TABLE

ABOUT

SIGN OUT

MAIN SHEET

PVT CALCULATOR

FLUID PROPERTIES IN OIL RESERVOIR

P =	4000	(psia)	CORRELATION
Pb =	3169.1794	(psia)	Vasquez-Beggs
Bo =	2.0334	(RB/STB)	Vasquez-Beggs
Rs =	2.0000	(Mscf/STB)	Vasquez-Beggs
Bg =	0.7412	(RB/Mscf)	Standard
Bw =	1.0313	(RB/STB)	Standard (McCain)
Rsw =	0.015102355	(scf/STB)	Standard (McCain)
Conditions =	UNDER SATURATED	Oil Saturation	
z =	0.9008	(vol/vol)	Hall - Yarborough
Oil Density =	34.3226638	(lbm/cf)	Standard
Gas Density =	15.7985	(lbm/cf)	Modification of EOS
Brine Density =	62.6422	(lbm/cf)	Standard (McCain)
Oil Viscosity =	0.1518	(cp)	Beggs - Robinson's
Gas Viscosity =	0.0301	(cp)	Lee-Gonzalez Eaking
Brine Viscosity =	0.4006	(cp)	Standard (McCain)
Co x 1E-5 =	2.9279	(1/MMpsi)	Vasquez-Beggs
Cg x 1E-5 =	16.4124	(1/MMpsi)	Dranchuk-Purvis-Robinson
Cw x 1E-5 =	0.3026	(1/MMpsi)	Standard (McCain)

HOME

PVT TABLE

PVT CHARTS

PVT CALCULATOR SHEET

PVT TABLE

FLUID PROPERTIES CORRELATION

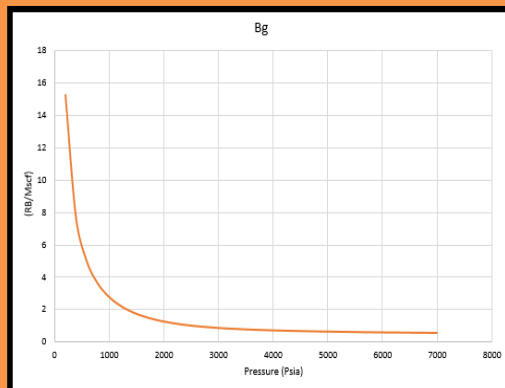
[illegible]

TABLE SHEET

PVT CHARTS

SELECT GRAPH

Gas Formation Volume Factor



HOME

PVT CALCULATOR

PVT TABLE

GRAFIK SHEET