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

$$a = 0.00091 (T - 460) - 0.0125 (API)$$

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

2) Vasquez-Beggs

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

with

$$a = -C_3 API/T$$

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 $T = temperature, {}^{\circ}R$

p = system pressure, psia

 γ_g = solution gas specific gravity

2) Vasquez-Beggs

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

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			
_						

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

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 Correlation

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

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 Correlation

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

$$m = 2.6 p^{1.187} 10^a$$

1.5 Oil Density

Standard method

$$\rho_{o} = \frac{62.4 \gamma_{o} + 0.0136 R_{s} \gamma_{g}}{B_{o}}$$

where γ_0 = specific gravity of the stock-tank oil

 $R_s = gas solubility, scf/STB$

 ρ_0 = oil density, lb/ft³

1.6 Oil Isothermal Compressibility (Co)

a. Saturated

: Correlation B-51 in McCain

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

b. Undersaturated : Vasquez-Beggz's correlation

$$c_o = \frac{-1,433+5R_{sb}+17.2(T-460)-1,180\,\gamma_{gs}+12.61^o\,API}{10^5\,p}$$
 where $T = \text{temperature},\,^\circ R$ $p = \text{pressure above the bubble-point pressure},\, psia$ $R_{sb} = \text{gas solubility at the bubble-point pressure}$

2. PVT GAS

2.1 Critical Properties (Ppc, Tpc, 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.

$$Ppc = \frac{P}{Pc}$$
$$Tpc = \frac{T}{Pc}$$

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

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

2.3 Z-Factor Calculation

Hall-Yarborough's Method

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

$$1 + T_1 \rho_r + T_2 \rho_r^2 + T_3 \rho_r^5 + [T_4 \rho_r^2 (1 + A_8 \rho_r^2)]$$

$$exp(-A_8 \rho_r^2)] - \frac{T_5}{\rho_r} = 0$$

$$\begin{split} T_1 = & \left[A_1 + \frac{A_2}{T_{pr}} + \frac{A_3}{T_{pr}^3} \right] \\ T_2 = & \left[A_4 + \frac{A_5}{T_{pr}} \right] \\ T_3 = & \left[A_5 A_6 / T_{pr} \right] \\ T_4 = & \left[A_7 / T_{pr}^3 \right] \\ T_5 = & \left[0.27 p_{pr} / T_{pr} \right] \end{split} \qquad \begin{array}{l} A_1 = 0.31506237 \\ A_2 = -1.0467099 \\ A_3 = -0.57832720 \\ A_4 = 0.53530771 \\ A_4 = 0.53530771 \\ A_8 = 0.68446549 \end{array}$$

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

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

Also.

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

2.6 Density Of Gas

Gas Equation of State Modification

$$R = 10.732$$

MW AIR =
$$28.965$$

Density of Gas = SG * Air Molar Weight * p / (Z * R * (T + 460))

2.7 Viscosity of gas (μ_g)

Lee-Gonzalez-Eaking Method

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

where

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

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

$$Y = 2.4 - 0.2 X$$

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

 \tilde{T} = reservoir temperature, ${}^{\circ}R$

Ma = apparent molecular weight of the gas mixture

3. PVT Formation Water

3.1 Water Formation Volume Factor (Bw)

McCain

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

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

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

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

- 3.2 Water Viscosity ($\mu_{\rm w}$)
 - 1) Standard Method

$$\begin{split} &\mu_{w} = \mu_{wD} \left[1 + 3.5 \times 10^{-2} \text{ p}^{-2} \left(\text{T} - 40 \right) \right] \\ &\underline{\mu_{wD}} = \text{A} + \text{B/T} \\ &\text{A} = 4.518 \times 10^{-2} + 9.313 \times 10^{-7} \, \text{Y} - 3.93 \times 10^{-12} \, \text{Y}^{2} \\ &\text{B} = 70.634 + 9.576 \times 10^{-10} \, \text{Y}^{2} \\ &: \mu_{w} = \text{brine viscosity at p and T, cp} \\ &\mu_{wD} = \text{brine viscosity at p} = 14.7, \text{T, cp} \\ &p = \text{pressure of interest, psia} \\ &T = \text{temperature of interest, T} \, ^{\circ} \text{F} \\ &\text{Y} = \text{water salinity, ppm} \end{split}$$

2) Beggs & Brill (1978)

Beggs & Brill (1978)

$$\mu_{\rm w} = \exp(1.003 - 1.479 \times 10^{-2} \,{\rm T} + 1.982 \times 10^{-5} \,{\rm T}^2)$$

3.3 Density of Brine

McCain

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

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

$$C_w = (C_1 + C_2T + C_3T^2) \times 10^{-6}$$

$$C_1 = 3.8546 - 0.000134 \text{ p}$$

 $C_2 = -0.01052 + 4.77 \times 10^{-7} \text{ p}$
 $C_3 = 3.9267 \times 10^{-5} - 8.8 \times 10^{-10} \text{p}$
 $T = {}^{\circ}\text{F}$
 $p = p \text{sia}$
 $C_w = p \text{si}^{-1}$

FEATURES ON SPREADSHEET

1. There are 5 sheets on our excel, which are:

a. Sign Inb. Main: Sheets where we input the oil field and the engineer: 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

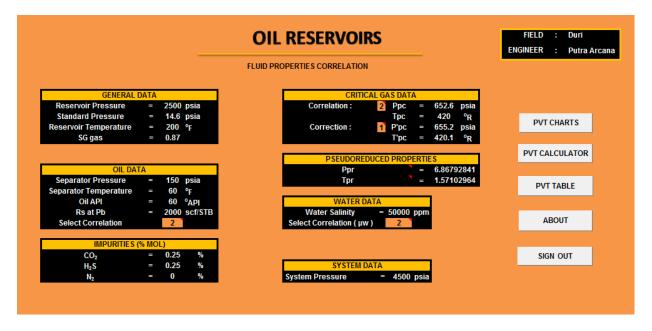
d. **Table** : Sheet that show the table of pressure for 36 pressures from initial reservoir pressure which is input value until pressure at standard condition

e. **Grafik** : Sheet that show the graph of the properties

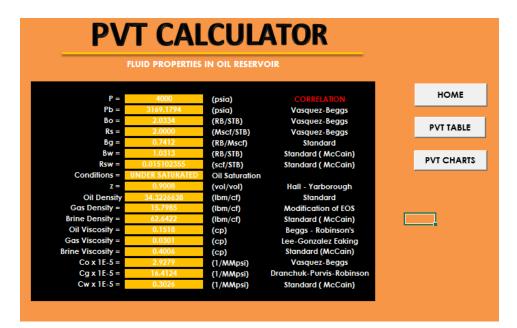
- 2. This excel can calculate the properties of oil, gas, and formation water.
- 3. The data of oil, gas, and separator can be input by user.
- 4. There is table that show all the result of properties calculation for different pressure.
- 5. We can see the graphs of each properties.
- 6. We can sign 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								
	a di Jatibarang								
Eng	gineer: Putra Arcana								
	SIGN IN								

SIGN IN SHEET



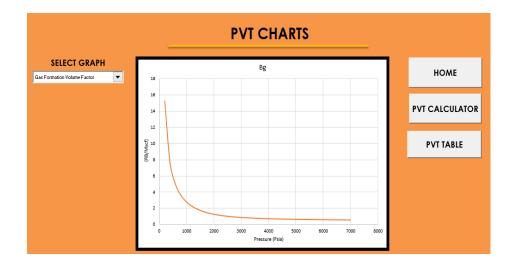
MAIN SHEET



PVT CALCULATOR SHEET

								P	VT TAB	LE							
		FLUID PROPERTIES CORRELATION															
HOME	Iprial	[p-1.4] 0-11-5.1 [H67570] [BD7570] [-p] [H7HHp-1][H761] [H761] [H-171] [BD7H61] [-p] [H7HHp-1] [H-67570] [BD7570] [-p]												[1788,]	pr		
HOME		Candillian	R.	.]	ш.	. [48 * 79.5		۵.	. 1		ш.	Cu [48 ' /pui]	B	I	ш.	C. [18" /***	
	7000	Under Salarated	2	1.55415584	1,21315575	1,67511771165	95,74587969	20.06566207	1,241117122		1.141414155	6.2113111133	0.024642065	1,0200252	1,2257925	1,211461	69,99222
T CALCULATOR	6885.56	Under Salarated	2			1.728775847			1.218365547	1.519249976	1.141751931	6.574764744	0.024207603	1.0200335	1.1536665	1.201033307	65.2785
TCALCULATOR	6611.55	Under Salarated	ž	1.56822551					1.195627116	1.535185527	1.040475005	6.000140243	1.121545151	1.8217554		8.285551575	69.22569
	8417.83	Under Salarated	z	1.515555555	1.4571155	1.024026537	55,54979898	15,46678574	1,172514462	0.604554545	1.0335(030)	7.252555576	LINESPESS	1.0225074	1.8511857	8.284765562	65,47441
PVT CHARTS	6555.06	Under Salarated	z	1.56748583	8.4525556	1.00174700	55,47978595	19.25842591	1.158236357	1.611838616	1.030034655	2,688463642	I.IRIBIBIR	1.0254005	1.5155775	0.206135545	65,4255
	6825.82	Under Salarated	2	1.57111156	1.41115166	1.542278546	55.41168252	19.82459791	1.42751143	1.615515171	1.131188833	1.121161441	1.14515414	1.0241555	3311333	8.287627557	65.0750
	5855.78	Under Salarated	2	1.57451556	RIBIE	2.116161133			1.185845415	1.623254944	1.197547775	8.472495666	8.845462542	1.0245655		1.215155524	51.1874
	\$541.75	Under Salarated	2	1.57524485		2.075074205			1.002567494	8.694576542	1.036050333	1.578562451	8.84985775	1.0257402		1.258454544	62.516121
	5447.71	Under Salarated		1.50500755	1.4772343	2.463113547	55.47555552	10.20001467	1.868197165	14616661511	8.83643646	5.524426558	8.848653654	1.0264502	1.2031111	8.251525855	13.55153
	5255.67	Under Salarated	2	1.511111572	1.4755686	2.2255155556	55.85112211	10.00752721	1.857565424	1.651 R1 (174)	1.055(1205)	18.15526524	1.141211413	1.0271610	1.65511158	8.233355886	T. 1888
	5859.64	Under Salarated	z	1.55428456	8.4655445	2.514655186	54.55647755	17.71891575	1.015050045	1441114141	8.854647456	10.01525062	1.047765050	1.0270591	1.6313136	8.254787875	THE REAL PROPERTY.
	4865.6	Under Salarated	z	2.111142424	1.1665605	8.417117518	50.03334076	17.41335538	1.350107131	1.002003337	1.055070755	11.5783696	1.1175116155	1.0205241	.551NH15H	1.236245164	B. 1110
	4674.57	Under Salarated	2	2.00647452	1.463316	2.516313371	50.78556655	17.03060371	1372031314	1.615168155	1.055070670	12.49785889	0.046035006	1.0251740	13(15)3(1	8.257654848	68,7697
	4477.55	Under Salarated	2	2.8455548	1.1555555	3.515535531	30.66411313	16.74785845	1.351432174	8.6552221641	1.052245466	19.48856746	8.846958699	1.1811131	0.5049456	1.2331113135	11011
	4285.45	Under Salarated		2.02036625	1.1565144	2.754185657	30.53483865	16.5006450	1.551527542	8.744862846	1.051555440	14.51128725	8.845859497	1.0304151	1.4555566	8.588545822	63,6561
	4113.46	Under Salarated		2.12323246	1.1551156	SHEETERS S	50.51201410	15.58866566	13113331071	BERTER BY	HISBRIE	15.77875599	1.015542521	1.0340007	1.0111127	0.50154701	1181.41
	5855.42	Under Salarated		2.03040743	1.4514174	5.116(13417	10.81786161	15.56886776	LEINII 659	1,75924753757	INTEREST	17.21792285	1.11(11125	1.0315741	DEFESTER.	8.585575757	14.1417
	5781.58	Under Salarated		2.0406346	1.1075105	5.464837457	REFERENCE	15.1158919	1.174217445	8.774745247	LINESSII	10.00075065	1.010200326	1.0321251	MOSSIII	1.514111714	14410
	5987.59	Under Salarated		2.16113144	13003777	3.3331(3133	33.1818811	14.62572224	никиин	1.111616167	ANTNI	20.03433037	1.119791907	1.0326510	BINSPER	LHROWS	144411
	5515.51	Under Salarated		SUBSTILIS	1.4443153	9331(3NKI)	33X113X13X	***************************************	RHNKH	REINNER	HISTORY III	25.48247767	1.1151115514	1.0351601	1.87(1994	1.517475755	62,5276
	5115.28	Salarated	15173778155	2.06545496	1.000	10.10160748	3334133311	19.51981695	RRINGSR	1.1666753865	HERRIE	25.7722784	0.042503427	1.0336402	1.203311	0.505407746	R.0111
	2525.24	Salarated	1.010610551	1.55455185	1.4631114	15.9644285	33.34843828	12.89157662	1.117271146	F11144114	1.124554515	21.53255537	1.1115551113	1.8341158	1.2102212	8.548555754	R.(1811)
	2751.2	Salarated	1.676925961	1.52458562	1.1035756	16.51715020	50.2851N185	12.21125152	0.755510744	1.555577 000	1.125446433	92.66214914	8.81155545	1.0345632	1.411475115	8.511571721	F2.4421
	2557.47	Salarated	1.555515555	1.155555522	1.45(164)	10.7562505	50.655166247	11.46594912	1.717211744	1.124323333	1.188331151	57.05214016	1.14177164	1.03(550)	1.464451	1.545415711	62,4478
	2545.45	Salarated	1.557511175	1.71755010	HEREI	REFERENCE	35.155(5717	18.66142616	1.7111111741	1.030344353	8.821183347	42.55551158	8.848448535	1.035337	1.4974517	8.514855656	141141
	2103.85	Salacated	1.251227487	1.72861641	HERRIE	25.61465574	35.41213461	3.758765256	1.711811117	1.1556565165	LINIBARIS	48.45587645	HIBBIRON	1.0357033	1.4454345	Burry	T#1514
	1555.86	Salarated	1.127258561	1.65473333	MMRNIR	26.34444713	HARMAN	HIRITIAN	MNNMH	1.517551666	REFERENCE	55.666551616	ппп	1.0361434	пини	8.51765567	12.51472
	1761.82	Salvealed	WHAT INDE					7.554526257		1.476979865	1.147133433	69.54742487	4811481111	1.8364354		B11111111	RARRE
	1566.99	Salvealed	MIHHMA	1.53(5)(1)	KIISIN	HATTISHE	36,32743334	6.956499746	HIEFHIER	1.11 111 1111 1111	MEISTERN	79.58211198	HINGSHI	1.1361213		1.581963649	14111
	1972.95	Salvealed	187(13)28523					5.578551478		15577223115	LIGHTSHIP	84.74159276	RITERIN	1.8971256		*********	THE I
	1178.51	Salarated	13111111111	1.000332		50.55111555				2.555157256	1.115224565	58.44458762	1.116113374	1.037(10)		13183188888	11.11
	584.877	Salarated	13335473113	1.50641177					RHIINN	8. N 1198815	1110527555	116.5114714	11135166617	1.0376747		1.58(155)617	144444
	750.041	Salarated	1,514,575762			35.45111747				5.677116554	. 4558 551	141.5171584	1.11(15)15(1	1.0375100		********	THE COLUMN
	556,005	Salarated	********	1.816(1)74						5.124557553	1.145424344	111111111111111111111111111111111111111	111111111111111111111111111111111111111	1.0501426		* HANARIA IS	12.2225
	402.760	Salarated	M25185403			201.7255117			133111133743	7.671143547	1.1611111111111111111111111111111111111	264.0334646	HEISTEIL	1.111111		********	138131
	288.752	Salarated	1.075206444					8.767264766		15.26116554	1.012602034	494.6296572	1.112542611.	1.1319331		1.551517556	11.11(1)
	14.656	Salvealed	1.113335841	4.41273622	BINGING	24648.96692	CHRIBIT	HINNEIN		229,9677824	HINGHIE	EVALUE:	1111935135	1.11111111	5.411E-II	BINKIKK	62.4546

TABLE SHEET



GRAFIK SHEET