Standard Volume

$$V_{sc} = \frac{RT_{sc}}{P_{sc}}$$

$$= \frac{10.732\ ft^3 \frac{psia}{lb - mol\ °R}(60 + 460°R)}{14.7\ psia}$$

$$V_{sc} = 379.6\ \frac{scf}{lb - mol}$$

If surface conditions are not STP (i.e 65°F rather than 60), use the above equation to get a standard volume - plug in the P_{sc} and T_{sc} values accordingly.

[Pseudo] Critical P/T

Finding Critical P/T (P_c, T_c) – if composition is known, use Kay's rule for finding the pseudocritical P/T. If gas contains impurities, correct for them. *(Textbook or google: there are many correlation equations hence one is not used here, welcome to Petroleum Engineering*)

Kay's Rules: $P_{pc} = \sum P_{ci}\,\gamma_i,\ T_{pc} = \sum T_{ci}\,\gamma_i$

Z-Factor

$$Z = \frac{V_{actual}}{V_{ideal}} = \frac{PV}{nRT} \qquad PV = nRT \qquad P_r = \frac{P}{Pc} \qquad T_r = \frac{T}{Tc}$$

(Use Z-factor chart if correlation is not going to be used)

$$Z = \frac{P(MW_{gas})}{\rho_{gas}\ RT}$$

Resources

Helpful resource for finding gas/hydrocarbon properties
http://Encyclopedia.airliquide.com/Encyclopedia.asp

Calculator for Z, Pseudocritical P/T given gas gravity
http://checalc.com/solved/naturalgasZ.html

Gas Density

$$\gamma_{gas} = \frac{\rho_{gas}\ @s.c.}{\rho_{air\ @\ s.c.}} = \frac{\rho_{gas}\ @s.c.}{0.0765\ \frac{lbm}{ft^3}\ (@60°F, 14.7\ psia)}$$

$$= \frac{(MW)_{gas}\ @s.c.}{28.97\ \frac{lbm}{lb - mole}}$$

$$\rho_{gas} = \frac{n}{V}(MW_{gas}) = \frac{P}{ZRT}(MW_{gas})$$

Moles, Molar Fractions

Common Hydrocarbon Properties

	MW (lbm/lb-mole)	P_c (psia)	T_c (°R)
N_2	28.01	492.6	227.4
H_2S	34.08	1305.3	671.6
CO_2	44.01	1069.9	547.8
C_1	16.04	673.1	343.2
C_2	30.07	708.3	549.9
C_3	44.10	617.4	666.0
i-C_4	58.12	529.1	734.6
n-C_4	58.12	550.1	765.7
i-C_5	72.15	483.5	829.6
n-C_5	72.15	489.8	846.2
n-C_6	86.17	440.1	914.2
n-C_7	100.2	395.9	972.4

$$C_g = -\left(\frac{1}{V}\right)\left(\frac{\partial V}{\partial P}\right)_T$$

$$°API = \frac{141.5}{\gamma_o} - 131.5$$

Formation Volume Factor

$$B_g = \frac{ZnRT/P}{Z_{sc}nRT_{sc}/P_{sc}}$$

$$B_g = 0.02827\ \frac{ZT}{P}\left[\frac{ft^3}{scf}\right] = 0.005035\ \frac{ZT}{P}\left[\frac{bbl}{scf}\right]$$

Hall-Yarborough Correlation (Z)

For spreadsheet applications there are several correlations available. Hall – Yarborough is as follows.

$$Z = \frac{(1 + x + x^2 - x^3)}{(1 - x)^3} - Ax + Bx^C$$

Where: $A = 14.76t - 9.76t^2 + 4.58t^3$

$$B = 90.7t - 242.2t^2 + 42.4t^3$$

$$C = 1.18 + 2.82t$$

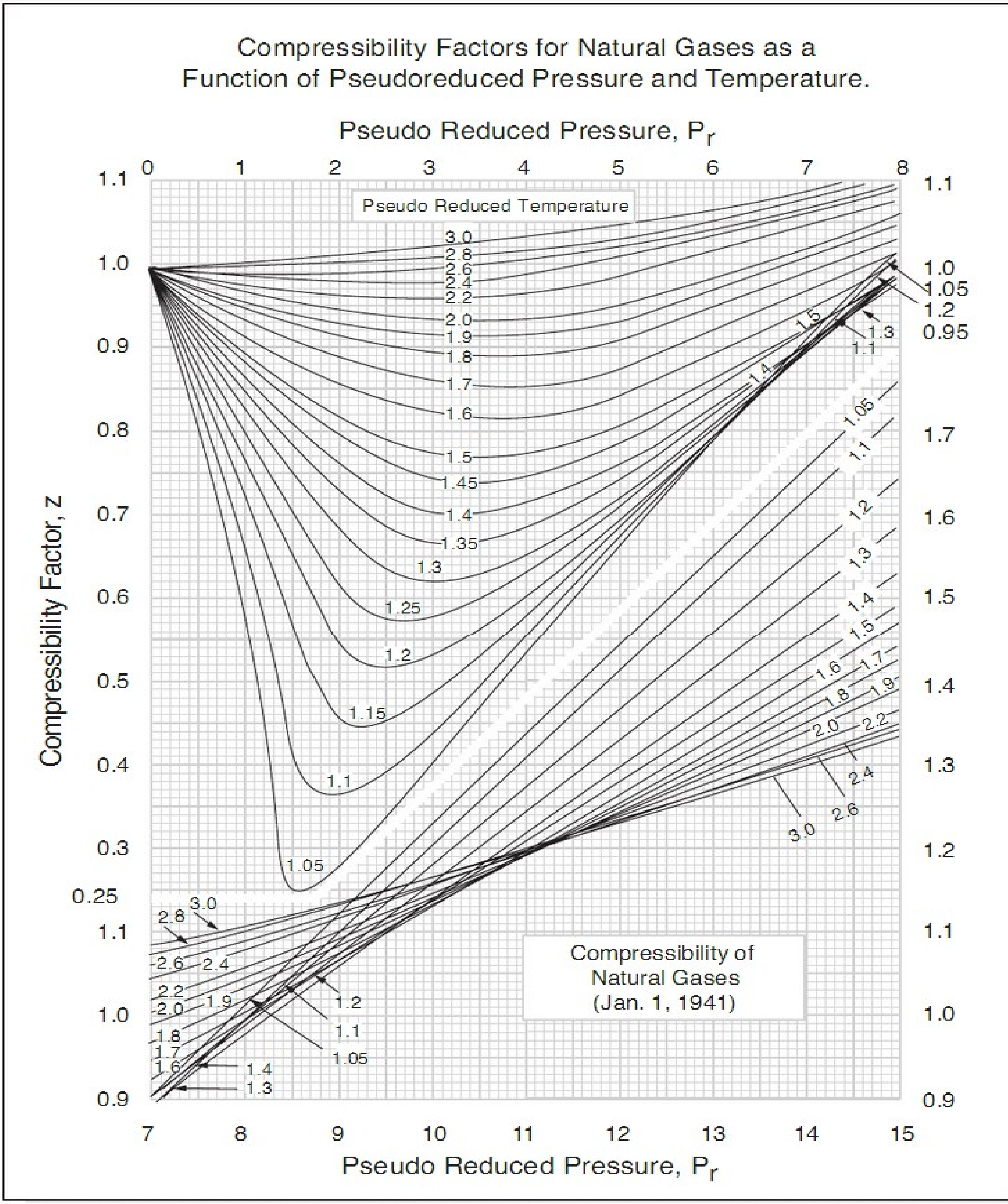
$$x = \frac{bp}{4ZRT} \qquad t = \frac{1}{T_R}$$

$$b = 0.245\left(\frac{RT_c}{P_c}\right)\exp[-1.2(1 - t)^2]$$

Note that x is a function of Z, to calculate have $Z_{assumed}$ (set equal to 1) plugged into x. and have $Z_{calculated}$ as the equation above. Have a column diff = $Z_{assumed}$ – $Z_{calculated}$, use goalseek to set 'diff' to 0 by adjusting $Z_{assumed}$. Excel will make an iterative calculation to adjust the assumed value.

General Classification of Reservoir Fluids

Reservoir Fluid	API Gravity	μ (cP)
Black Oil	15-40	2 to 3 - 100
Volatile Oil	45 – 55	0.25 range
Gas Condensate	>50	0.25 range
Dry Gas	-	0.02 – 0.05


Compressibility Factors for Natural Gases as a Function of Pseudoreduced Pressure and Temperature.
Pseudo Reduced Pressure, Pr
Pseudo Reduced Temperature
Compressibility Factor, z
Compressibility of Natural Gases (Jan. 1, 1941)
Pseudo Reduced Pressure, Pr