Properties of Reservoir Fluids (PGE 362)

# Reservoir Fluids Characteristics

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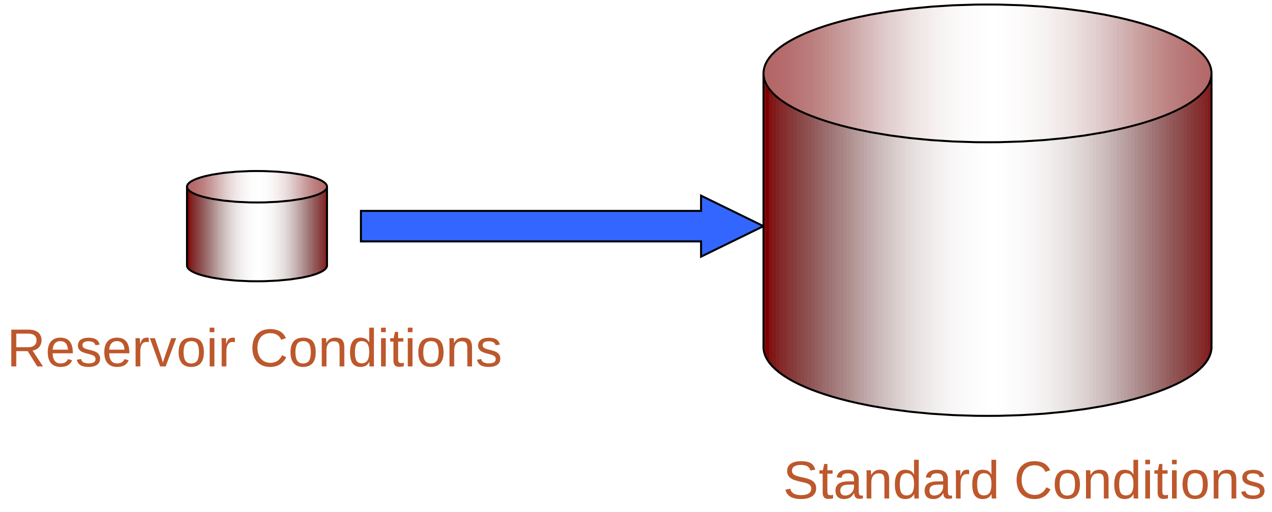
# Gas Properties

Gas Formation Volume Factor (Bg):

The volume of gas at reservoir conditions required to produce one standard volume of gas at the surface condition.



# Gas Properties

## Gas Formation Volume Factor (Bg):

$$B_g = \frac{V_R}{V_{SC}} = \frac{\frac{znRT}{P}}{\frac{nRT_{SC}}{P_{SC}}}$$

SC: $P$ =14.65 psia, $T$ = 520 °R, $z$ = 1.0

$$B_g = \frac{P_{SC}}{T_{SC}} \frac{zT}{P} = \frac{14.65}{(520)} \frac{zT}{P} = 0.0282 \frac{zT}{P} \frac{res\ cu\ ft}{scf}$$

$$B_g = 0.00502 \frac{zT}{P} \frac{res\ bbl}{scf}$$

$$B_g = 5.02 \frac{zT}{P} \frac{res\ bbl}{Mscf}$$

Volume of an arbitrary amount of gas at reservoir T & P

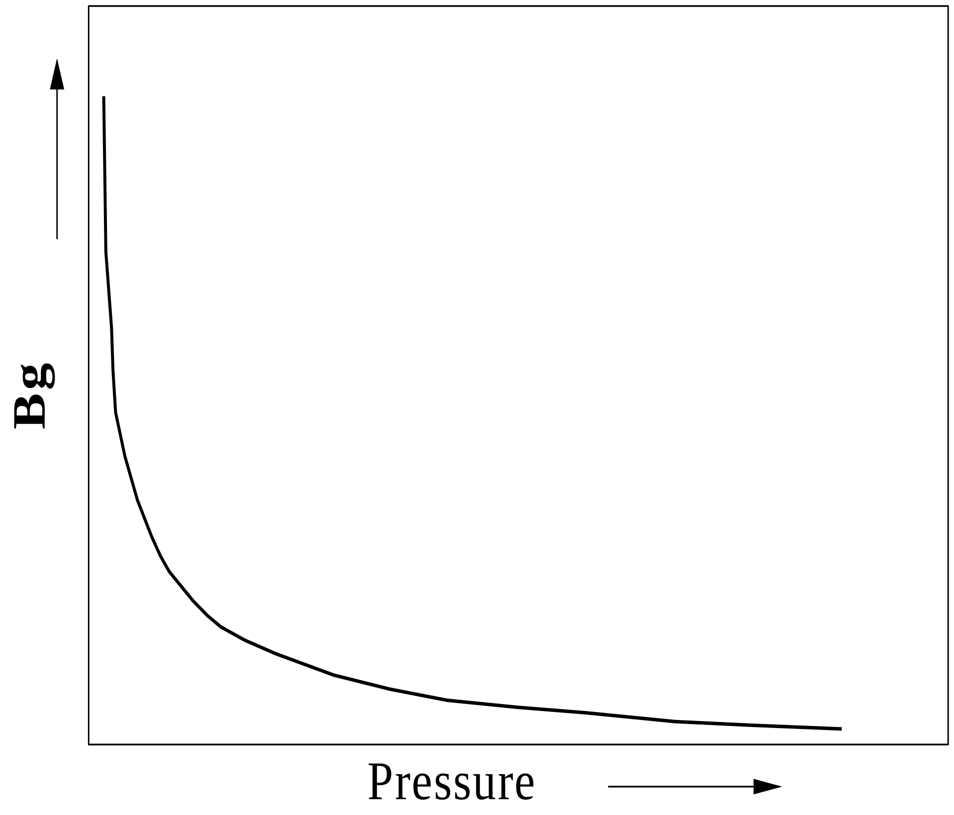
Volume at SAME amount At standard T & P

$$B_g = \frac{V_R}{V_{SC}}$$

# Gas Properties

Gas Formation Volume Factor (Bg):

Typical shape of Bg



# Gas Properties

Gas Formation Volume Factor (Bg):

Example:

A gas has a specific gravity of 0.74. Calculate its formation volume factor at 210° F and 2300 psia.

Solution:

$Tc$ = 396° R, $Pc$ = 665 psia

$$T_r = \frac{460+210}{396} = 1.69,\ P_r = \frac{2300}{665} = 3.46\ ,\ z = 0.86$$

$$B_g = 0.00502\ \frac{(0.86)(670)}{(2300)} = 0.00126\ \frac{res\ bbl}{scf} = 1.26\frac{res\ bbl}{Mscf}$$

# Gas Properties

Gas Viscosity ($\mu_g$):

Viscosity is a measure of the resistance to flow exerted by a fluid.

Units:

Dynamic ($\mu$): Poise (p) = g mas/(sec cm)

or centipoise (cp) = g mas/(100 sec cm)

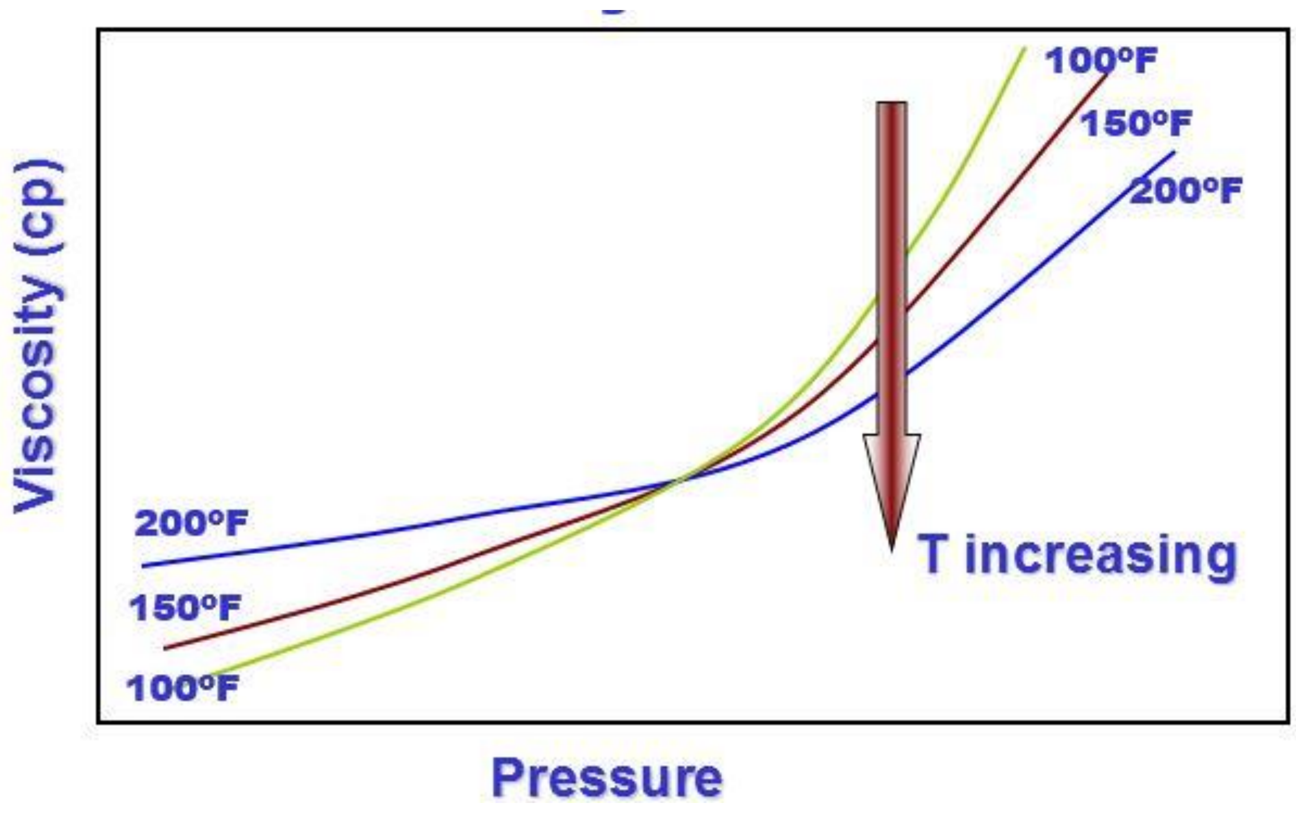
SI unit : Pascal second (Pa s) = 1 kg/(m s) = 10 p

Kinematic ($v$): viscosity/density : centipoise/gm/cc (cp/g/cc)

# Gas Properties

Gas Viscosity ($\mu_g$):

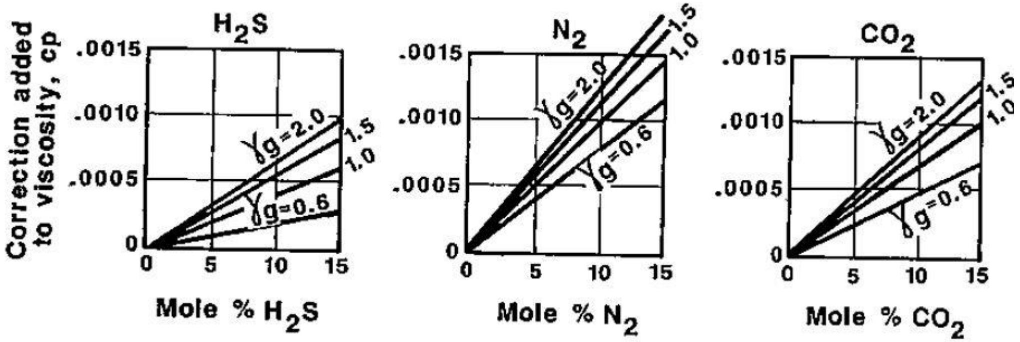
<u>Typical shape</u>:

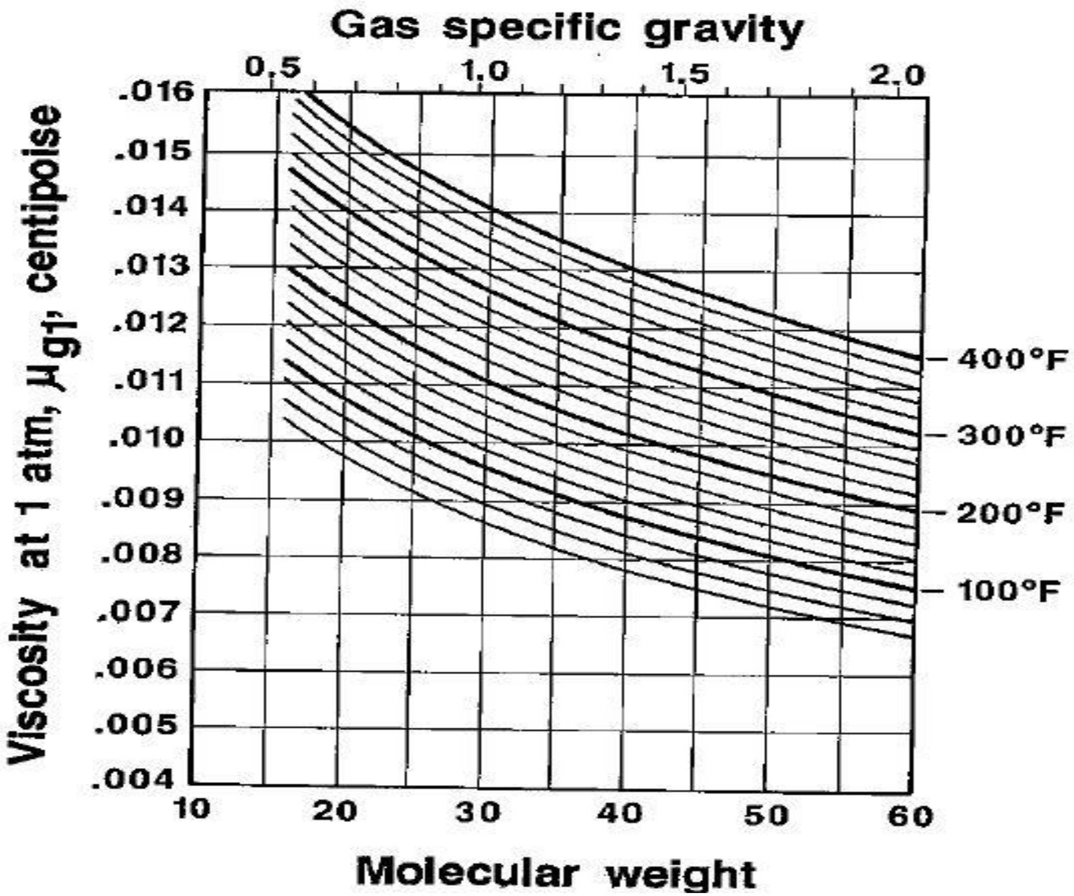


# Gas Properties

Gas Viscosity ($\mu_g$):

Correlation:



# Gas Properties

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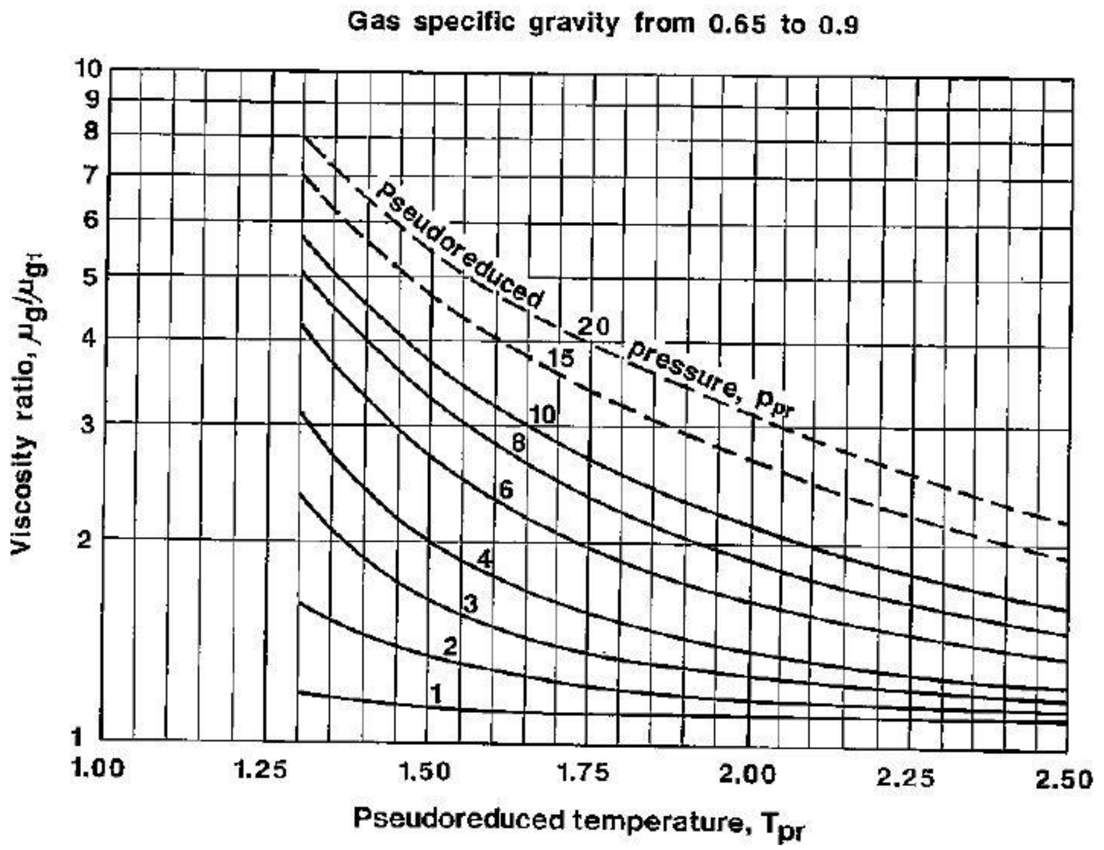

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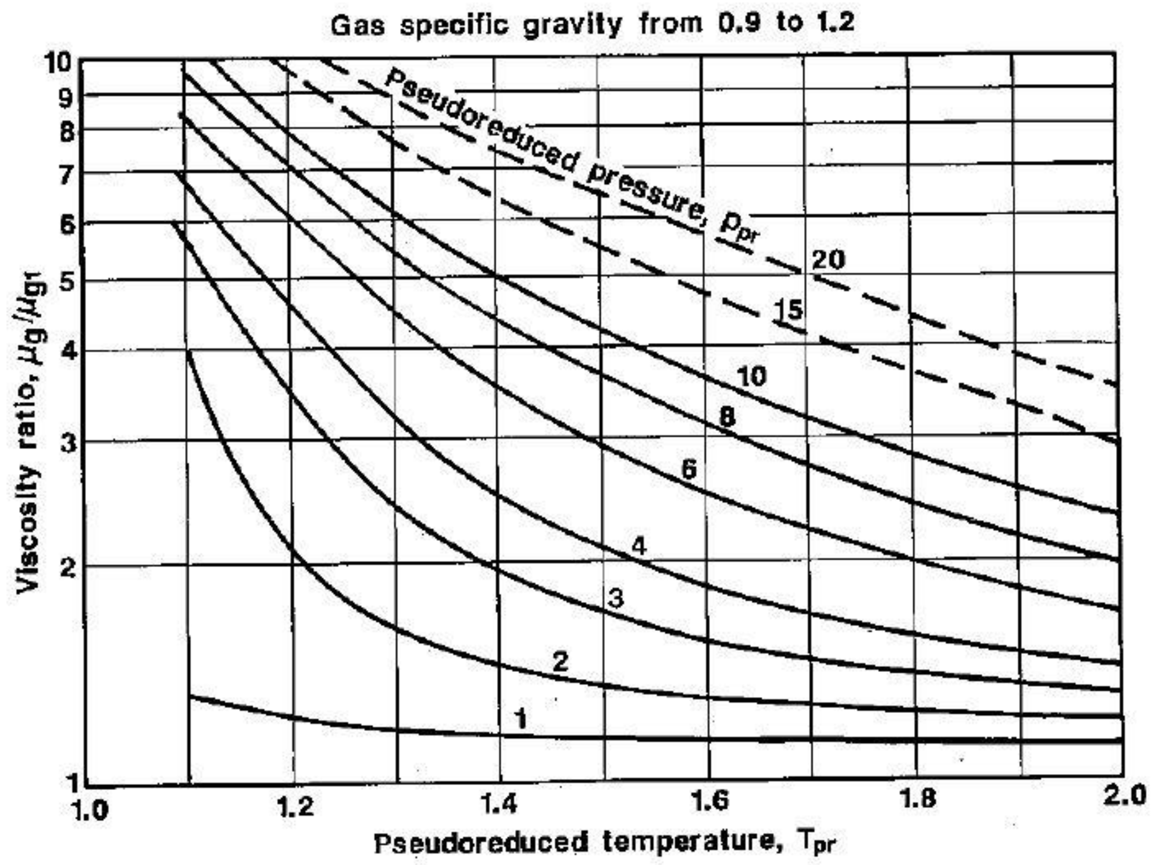
Gas Viscosity ($\mu_g$):

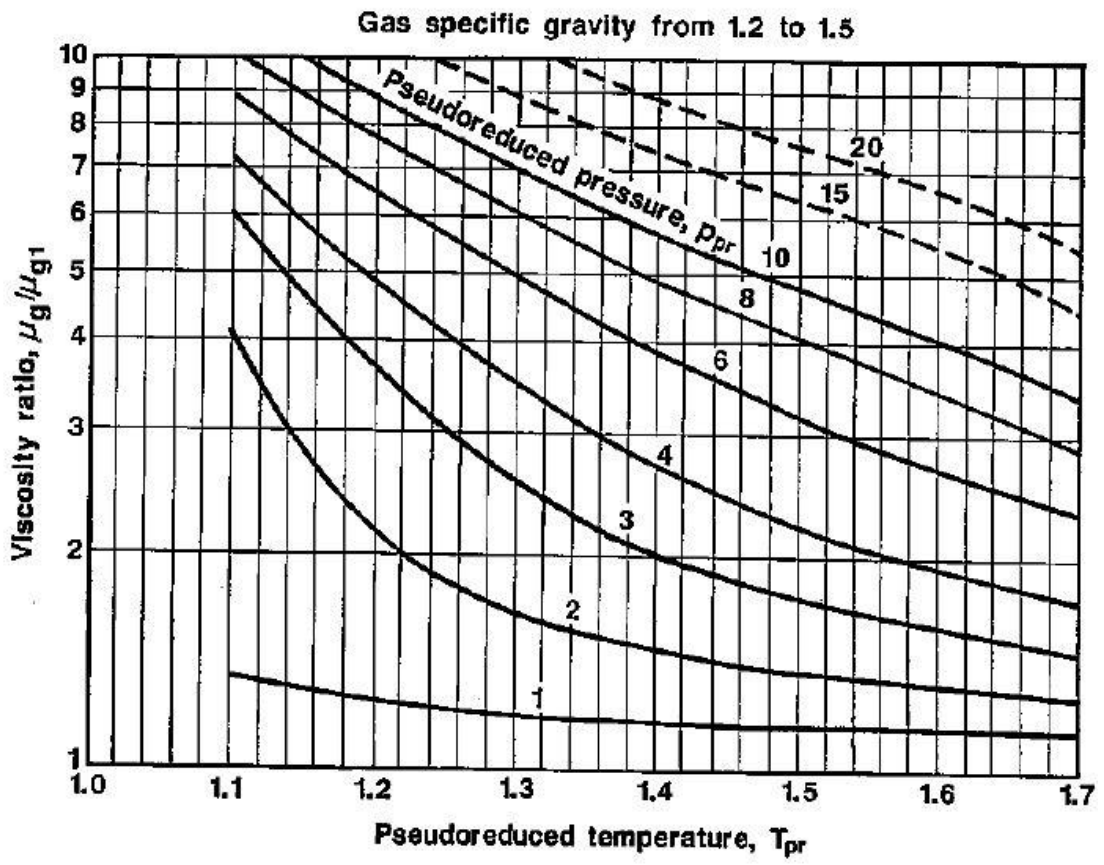
<u>Correlation</u>:



# Gas Properties

Gas Viscosity ($\mu_g$):

<u>Correlation</u>:



# Gas Properties

Gas Viscosity ($\mu_g$):

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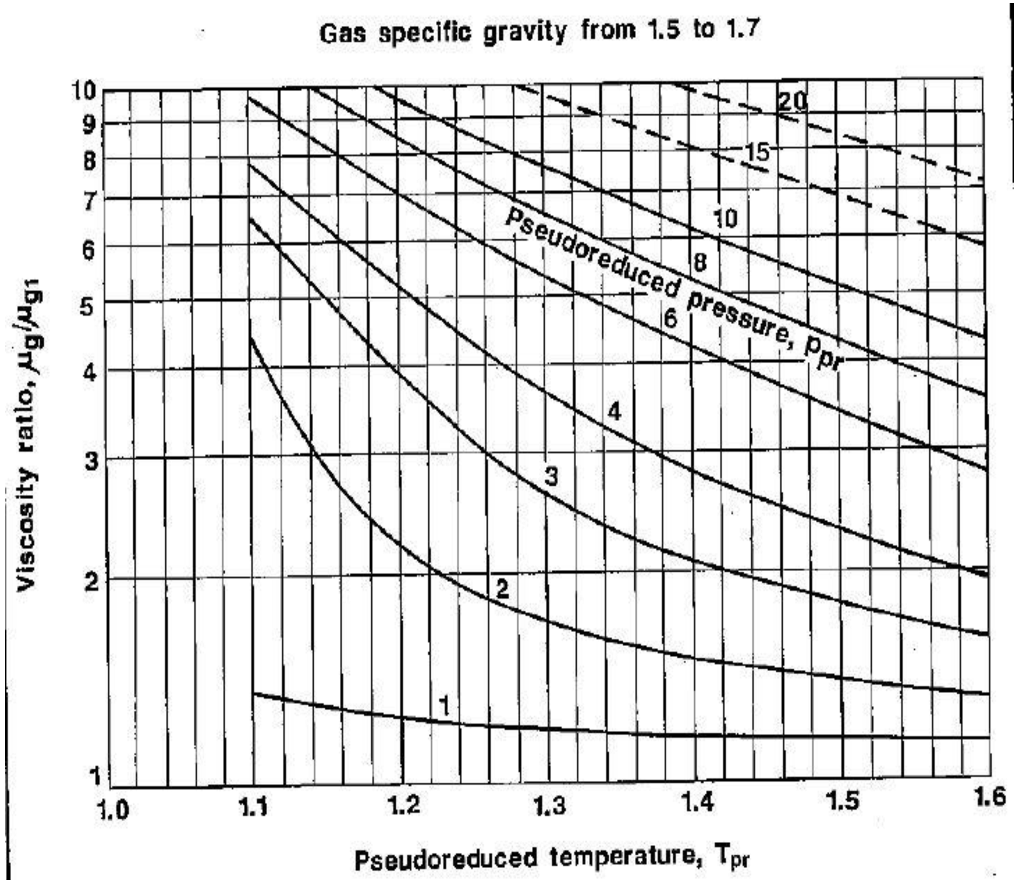


# Gas Properties

Gas Viscosity ($\mu_g$):

<u>Correlation</u>:

EXAMPLE 6–9: *Calculate the viscosity of the gas mixture given below at 200°F and a pressure of one atmosphere absolute.*

| Component | Composition, mole fraction |
|---|---|
| Methane | 0.850 |
| Ethane | 0.090 |
| Propane | 0.040 |
| n-Butane | 0.020 |
| | 1.000 |

# Gas Properties

Gas Viscosity ($\mu_g$):

Correlation:

Solution:

First, calculate the specific gravity of the gas.

$$M_a = \sum_j y_j M_j$$

| Component | $y_j$ | $M_j$ | $y_j M_j$ |
|---|---|---|---|
| $C_1$ | 0.85 | 16.04 | 13.63 |
| $C_2$ | 0.09 | 30.07 | 2.71 |
| $C_3$ | 0.04 | 44.10 | 1.76 |
| $n\text{-}C_4$ | 0.02 | 58.12 | 1.16 |
| | 1.02 | $M_a$ | 19.26 |

$$\gamma_g = \frac{M_a}{29}$$

$$\gamma_g = \frac{19.26}{29} = 0.664$$

Second, determine viscosity.

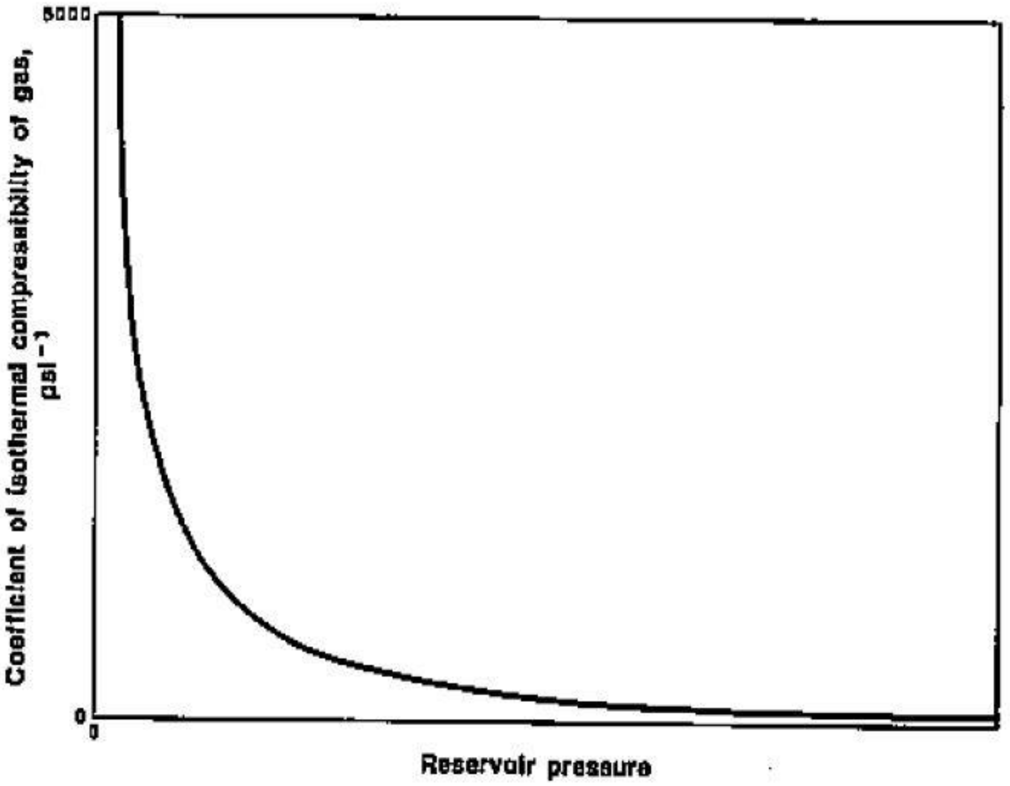
$$\mu_{g1} = 0.0125 \text{ cp at } 200°F, \text{ Figure } 6\text{–}8$$

# Gas Properties

Coefficient of Isothermal Compressibility of Gas ($c_g$):

The change in gas volume per change in pressure at constant temperature.

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



# Gas Properties

Coefficient of Isothermal Compressibility of Gas ($c_g$):

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

Ideal Gas: $V = \frac{nRT}{P}: \frac{\partial V}{\partial P} = -\frac{nRT}{P^2}$

$$c_g = -\left(\frac{P}{nRT}\right)\left(-\frac{nRT}{P^2}\right) = \frac{1}{P}$$

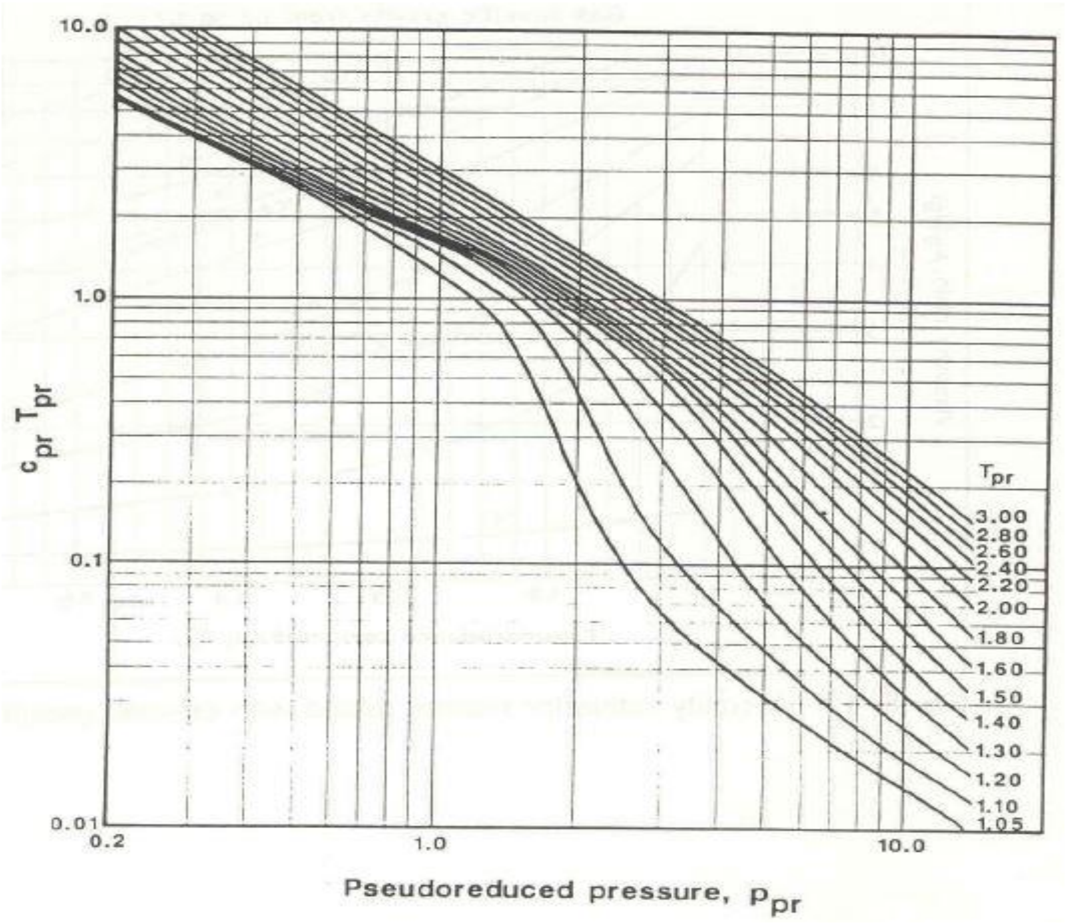
Real Gas: $V = \frac{znRT}{P}: \frac{\partial V}{\partial P} = nRT\,\frac{P\left(\frac{\partial z}{\partial P}\right)_T - z}{P^2}$

$$c_g = -\left(\frac{P}{znRT}\right)\left[nRT\,\frac{P\left(\frac{\partial z}{\partial P}\right)_T - z}{P^2}\right]$$

$$c_g = \frac{1}{P} - \frac{1}{z}\left(\frac{\partial z}{\partial P}\right)_T$$

# Gas Properties

Coefficient of Isothermal Compressibility of Gas ($c_g$):



# Gas Properties

Coefficient of Isothermal Compressibility of Gas ($c_g$):

Example:

Calculate the coefficient of isothermal compressibility of a dry gas with specific gravity of 0.818 at reservoir temperature of 220° F and 2100 psig.

Solution:

$T_{pc} = 406° R$

$P_{pc} = 647$ psig

$C_{pr} = c_g p_{pc}$

$$T_{pr} = 1.68 \text{ and } p_{pr} = 3.27$$

using appropriate $c_{pr}T_{pr}$ chart.

$$c_{pr}T_{pr} = 0.528$$

$$c_{pr} = \frac{0.528}{1.68} = 0.314$$

$$c_g = \frac{c_{pr}}{p_{pc}} = \frac{0.314}{647 \text{ psia}} = 486 \times 10^{-6} \text{ psi}^{-1}$$